Identification and Characterization of Arctic Nearshore Benthic Habitats

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Fisheries and Aquatic Sciences 1434

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by

D.H. Thomson, C.M. Martin and W.E. Cross

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This is the 192nd Technical Report
from the Western Region, Winnipeg

PREFACE

This is the final report of work conducted under the terms of a Department of Supply and Services contract issued to LGL Ltd., environmental research associates (DSS Contract No. OSF 84-00100). The scientific authority was B.W. Fallis, Department of Fisheries and Oceans, Western Region, 501 University Crescent, Winnipeg, Manitoba, R3T 2N6.

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ABSTRACT

Thomson, D.H., C.M. Martin, and W.E. Cross. 1986. Identification and characterization of Arctic nearshore benthic habitats. Can. Tech. Rep. Fish. Aquat. Sci. 1434: vii + 70 p.

Infaunal samples (n = 460) from depths of 1-55 m at 25 sites in the eastern and central Canadian Arctic islands were analyzed. Nine infaunal species assemblages defined by factor analysis were, for the most part, not restricted in their geographical distribution but did show evidence of depth and substrate preferences. An assemblage that included the bivalve Portlandia arctica was characteristic of fine silt substrates; coarser heterogeneous substrates often supported assemblages that included the bivalves Macoma calcarea, Astarte borealis and other species. Assemblages that included amphipods were characteristic of shallow depths, and assemblages that included the polychaetes Maldane sarsi and Owenia fusiformis, the bivalve Nuculana minuta, and cumaceans were characteristic of deeper water. These assemblages also showed different substrate associations. Depth, substrate, exposure, mortality and food supply appeared to be major determinants of standing crop and community structure.

The upper 3-5 m was usually depauperate of infauna due to variations in temperature and salinity and presence of ice. The barren zone extended to deeper depths in exposed locations, as did the depth of maximum standing crop. The productivity to biomass ratio of bivalves was only about 0.1-0.2 but total productivity was moderately high. Predation on the infauna appears to be at a constant low level and mortality of the infauna is low. The infauna is characterized by a preponderance of old large individuals and likely represents the climax condition.

Rock substrates were characterized by chitons, gastropods and sessile epifaunal forms such as barnacles, mussels, anemones, tunicates, sponges and hydrozoans. Biomass on rock surfaces often was high and comparable to that of the infauna. Sea urchins were common in all areas with seaweed and their biomass may also be high.

Quantitative intertidal samples (n = 234) from 16 locations in the central and eastern Canadian Arctic islands were analyzed. The intertidal zone was devoid of sessile and infaunal animals and macroalgae. Amphipods, chiefly Gammarus setosus, Onisimus litoralis, O. glacialis and O. nansenl, were the dominant animals in the intertidal zone. All were most abundant at low tide. Density of Gammarus setosus was highest on rock substrates and high densities of Onisimus species were associated with sand.

Amphipods and mysids were the dominant epibenthic animals in the subtidal zone. Amphipods were more abundant in shallow water at exposed locations than at sheltered locations. Mysids sometimes form dense shoals in shallow water and just over the bottom in deeper water.

Key words: Canadian high Arctic; marine benthos; intertidal; amphipods; distribution; abundance; productivity; community structure.

RÉSUMÉ

Thomson, D.H., C.M. Martin, and W.E. Cross. 1986. Identification and characterization of Arctic nearshore benthic habitats. Can. Tech. Rep. Fish. Aquat. Sci. 1434: vii + 70 p.

Des échantillons endofauniques (au nombre de 460) recueillis à des profondeurs variant de 1 à 55 m à 25 endroits dans les îles de l'est et du centre de l'Arctique canadien ont été analysés. Neuf (9) groupes d'espèces endofauniques, définis par analyse factorielle, n'étaient pas, pour la plupart, associés à des secteurs géographiques déterminés, mais avaient des points en commun en ce qui concerne la profondeur de l'habitat et le type de substrat. Un groupe dont faisait partie le bivalve Portlandia arctica était caractérisé par les substrats de limon fin tandis que les substrats hétérogènes, d'éléments plus gros, logeaient souvent des groupes où se retrouvaient les bivalves Macoma calcarea, Astarte borealis et d'autres espèces. Les groupes comptant des amphipodes se retrouvaient à de faibles profondeurs tandis que ceux qui comptaient entre autres les polychètes Maldane sarsi et Owenia fusiformis, le bivalve Nuculana minuta et les cumacés se retrouvaient surtout à des profondeurs plus grandes. Ces groupes se trouvaient également sur divers autres substrats. La profondeur, le substrat, l'exposition, la mortalité et la nourriture semblaient être les principaux facteurs déterminants de la biomasse et de la structure communautaire.

La strate de 3 à 5 m de la surface était habituellement dépourvue d'endofaune, étant donné les variations de température et du degré de salinité ainsi que de la présence de glace; l'épaisseur de cette strate est plus grande encore dans les endroits exposés et la biomasse maximale, pour cette raison, se trouve elle aussi à une profondeur plus grande. Le rapport de la productivité la biomasse des bivalves n'était que d'environ 0,1 à 0,2, mais la productivité totale était passablement élevée. La prédation dont fait l'objet l'endofaune semble être constante et peu élevée, et la mortalié y est basse. L'endofaune est caractérisée par la prépondérance de sujets âgés, gros, et cet état représente vraisemblablement les conditions de développement maximales.

Les substrats de roche étaient caractérisés par la présence des chitons, des gastéropodes et des formes épifaunales sessiles telles les anatifes, les moules, les anémones, les tuniciers, les éponges et les hydrozoaires. La biomasse sur les surfaces des roches était souvent élevée et comparable à celle de l'endofaune. Les oursins se retrouvaient dans tous les secteurs où il y avait des algues et il se peut que leur biomasse soit élevée.

Des échantillons intertidaux quantitatifs (au nombre de 234) prélevés à 16 endroits dans les îles du centre et de l'est de l'Arctique canadien ont été analysés. La zone intertidale n'abritait pas de créatures sessiles ou endofauniques ni de macroalgues. Les amphipodes, surtout les Gammarus setosus, les Onisimus litoralis, les O. glacialis et les O. nanseni, y étaient les espèces dominantes. Toutes étaient des plus abondantes à marée basse; les densités de Gammarus setosus les plus élevées se trouvaient sur les substrats de roche et des densitées élevées d'espèces d'Onisimus étaient associées aux fonds de sable.

Les amphipodes et les mysidacés étaient les espèces épibenthiques dominantes dans la zone subtidale. Les amphipodes étaient plus abondants en eau peu profonde, dans les endroits exposés, que dans les endroits non exposés. Les mysidacés forment quelquefois des bancs denses en eau peu profonde et à peu de distance du fond, en eau plus profonde.

Mots-clés: Arctique canadien; benthos marin; zone intertidale; amphipodes; distribution; abondance; productivité; structure communautaire.

INTRODUCTION

This report describing the benthos of 25 locations in the central and eastern Canadian Arctic islands was produced by one of Fisheries and Ocean's projects approved by the Northern Oil and Gas Action Program (NOGAP). Objectives of this program are to identify and characterize Arctic marine areas of significance to marine fish and mammals. Studies in ecologically discrete habitats (e.g. estuaries, nearshore waters) are planned to define ecological processes and the ecological requirements of marine species, and eventually to assess the vulnerability and sensitivity of these habitats to activities related to hydrocarbon development. Such information would be useful in (1) delineating areas that should receive attention when planning oil spill countermeasures or tanker routes, (2) selecting the most common and representative organisms for monitoring studies, and (3) distinguishing effects of industrial activities from those attributable to natural phenomena.

Some critical Arctic marine areas are presently known (e.g. Creswell Bay, Lancaster Sound), but knowledge of the conditions and processes responsible for concentrations of fish or marine mammals in these and other habitats is rudimentary. An important first step toward developing a capability to identify and characterize such critical habitats would be an analysis of regional variation in biotic and abiotic factors that may affect vertebrate abundance and distribution. Also of interest are the interactions among biotic and abiotic factors; the latter could be used to predict the faunal characteristics of different locations with a considerable reduction in sampling effort.

Among the biotic factors of potential importance to Arctic marine fish and mammals in nearshore habitats are the abundance, species composition and community structure of benthos. Early descriptions of various aspects of Arctic benthos were given by Thorson (1957), Ockelmann (1958), and Ellis (1960). Since that time, considerable effort has been directed toward Arctic marine studies related to oil and gas exploration. In spite of these efforts, however, "knowledge of the structure and dynamics of polar marine communities lags far behind that of other areas" (Percy 1982:103).

For the present purposes, the term 'benthos' refers to animals occupying three different habitats: infaunal, epibenthic and intertidal. Each of these types of animals is a food source for higher trophic levels: walrus and bearded seals (infauna), ringed seals and Arctic char (epibenthic amphipods and mysids), shorebirds and some marine birds (intertidal amphipods), and marine fish (all three types of benthos). Infaunal animals are best suited for monitoring purposes because of their sedentary habits and their ability to accumulate pollutants (e.g. Teal and Howarth 1984), whereas epibenthos is generally considered to be less suitable for monitoring because mortality and emigration are difficult to distinguish (cf. Elmgren et al. 1983). Intertidal animals are of particular concern because of their susceptibility to effects of beached oil slicks (e.g. Cross and Martin 1983). During winter and spring, some intertidal and benthic animals (primarily amphipods) inhabit the under-ice surface, another habitat of considerable concern with respect to oil spill (or blowout) countermeasures.

During the past decade, LGL Limited, environmental research associates, has sampled intertidal and nearshore benthos in a number of locations in the central and eastern part of the Canadian high Arctic. In spite of the large number and wide distribution of these locations, the only comprehensive study of regional variation in benthic communities was for the Lancaster Sound-Baffin Bay area during the Eastern Arctic Marine Environment Studies (EAMES) study in 1978 and 1979 (Thomson and Cross 1980; Thomson 1982). Benthic and intertidal samples collected during 1974-1977 were either not analyzed or were analyzed and reported on a site-specific basis (Buchanan et al. 1977; Thomson et al. 1978). Samples collected during 1980-1983 Baffin Island Oil Spill (BIOS) project; (Cross and Thomson 1981, 1982; Cross et al. 1983, 1984) provided much information on temporal variability and small scale spatial variability but were limited in geographical coverage. Locations sampled during 1974-1983 are shown in Fig. 1.

In the present study, regional variation in benthic and intertidal biota of the central and eastern Canadian Arctic is analyzed. Benthic communities are identified and the roles of depth, substrate, exposure, food supply and predation in structuring these communities are identified. Some of the sampling sites were heavily utilized by beluga whales, walruses and Arctic char. Ringed seals and lesser numbers of bearded seals were widely distributed throughout all the areas studied. The sampling sites included areas of open coastline, estuarine areas, and areas within open and semienclosed bays and inlets. All study sites were unpolluted and located well away from human influences. The wide range of habitats and the wide geographical coverage contributed to the objectives of NOGAP because the results will assist in: (1) selecting the most common animals for monitoring studies, (2) distinguishing effects of industrial activities from natural phenomena, and (3) assessing vulnerability and sensitivity of habitats to hydrocarbon development-related activities.

MATERIALS AND METHODS

SAMPLING LOCATIONS

Locations where samples were collected during 1974-1983 are shown in Fig. 1. Sampling locations within bays are depicted in greater detail than are the majority of the locations, where the shoreline consisted of open coast or rocky headlands. At each location, subtidal samples were collected at a range of depths 2-55 m on one or more transects perpendicular to the shoreline. Intertidal samples were collected along the shore within 50-100 m on either side of the subtidal transect. Numbers of samples collected by each sampling method in

each location are shown in Table 1. For comparative purposes, samples collected at depths of 56-500 m in the eastern high Arctic (Thomson 1982) and in Barrow Strait in 1974 from 'CSS Hudson' (Table 1) were also used.

SAMPLING PROCEDURES

Subtidal fauna

In most locations, samples of infauna were collected with a 0.05 m^2 Ponar grab sampler. A 0.13 m^2 Van Veen grab and a 0.02 m^2 Ponar grab were also used. The Ponar grab is similar in construction and operation to the Van Veen grab described by Holme (1971).

At some locations in water depths ≤20 m, a diver-operated airlift sampler was also used. The airlift sampler consisted of a weighted 2 m length of pipe 8 cm in diameter fitted at the top with a 1 mm mesh net which retained the sample and could be removed quickly and capped. Air was supplied from a 20 MPa air cylinder fitted with a first stage of a diving regulator, which reduced air pressure to approximately 860 kPa above ambient. Areas to be sampled were demarcated with a ring containing an area of 0.0625 m^2, or with three 0.15 m^2 rings in a triangular array with centres 1 m apart. The 0.0625 m^2 ring was open at the top, whereas the 0.15 m^2 rings were covered with 1 mm mesh netting containing a quick release fitting to receive the distal end of the airlift tube.

Differences between samplers in sampling effectiveness, including depth of penetration into the sediment, are discussed below.

Results for epibenthos are based on three main types of sampling. Small, free-swimming amphipods (e.g., lysiannasids) were collected in the grab and airlift samplers described above. Larger epibenthic organisms (e.g. echinoderms and decapods) were collected with trawls towed parallel to shore near the infaunal sampling transects. A small (2.5 m) Otter trawl was used most often; in some locations a 5 m Otter trawl or a Cobb trawl was used (Table 1). Observations and collections were made by divers in randomly selected large areas. All large conspicuous animals were counted and, in some instances, collected for biomass estimates or positive identification. At one location, sessile animals were scraped from a delineated area on the rock and collected with the airlift.

Intertidal fauna

Intertidal zone sampling was carried out at or near low tide. A 0.25 m^2 quadrat (15 cm high) was placed in the water 0.5 m seaward from the water line, the substrate was manually disturbed, and all of the enclosed animals were removed by using a small aquarium net.

Physical and chemical environment

Water samples collected in conjunction with sampling of subtidal benthos were analyzed for temperature and salinity using a reversing thermometer and either a Hytech Induction Salinometer (Model 6220; ± 0.001) or an Endeco handheld refractometer/salinometer (± 0.2). Chlorophyll *a* concentrations were measured by standard methods (Strickland and Parsons 1972). Macronutrient concentrations (orthophosphate, nitrate-nitrite and silicate) were measured using a Technicon Auto Analyzer II. Samples were taken at the surface, 7.5 m, 15 m, 25 m and 40 m depths at three or more locations per site. After filtration, nutrient samples were frozen immediately (sites A, C, F1, G, J, K, L, S, U); were frozen with dry ice (sites M, N, O, P, R); or were preserved with a few drops of chloroform and buried in the permafrost (sites I, T).

Depth profiles for subtidal transects were established by measuring depth with a Furuno echo sounder (FG 11 MK 3) mounted on an inflatable boat. Depth was measured with a sounding line or meter wheel at grab stations, and with capillary depth gauges at diver-operated airlift stations. At most locations (see Table 1), characteristics of the substrate in all grab samples and at all airlift sampling locations were assessed visually, and presence or absence was recorded for the following substrate categories: rock, cobble, pebble, sand, sandy silt, silt, silty clay and clay. At some locations, sediment subsamples were taken for later analysis of particle size distribution and organic content. For comparative purposes, detailed grain size data were reduced to the level of visual assessment by considering each of the following categories to be present if it constituted >10% of the sample: pebble (>2 mm), sand (0.0625-2 mm), silt (0.0031-0.0625 mm), and clay (<0.0031 mm).

At intertidal sampling locations, temperature and salinity were measured with a Yellow Springs Instrument (Model 33) temperature-salinity meter. Intertidal substrates were assessed visually, and an estimate of percent cover within the sampling quadrat was recorded for each of the following categories: rock (>5 cm), cobble (1-5 cm), pebble (2-10 mm), sand, silt and clay. The slope of the beach was estimated by measuring water depth at the seaward and shoreward sides of the sampling quadrat.

Exposure indices were calculated using the cartographic method of Baardseth (1970). The indices express exposure as the number of sectors of open water facing a site. For the present study, we used 10° sectors, and subdivided a total radius of 20 km into four 5-km annuli. Thus a totally open site would have 36 x 4 = 144 open sectors. A site that was 50% open to a distance of 20 km would have an index of 72. Sites open to Baffin Bay were further differentiated from sites open to the relatively narrow channels of the central archipelago.

LABORATORY PROCEDURES

The present study incorporates results obtained from a number of different periods of analysis (Fig. 1, Table 1). Sorting of samples from locations previously reported (Table 1) was completed within six months of collection. Laboratory analysis of unanalyzed and partially

analyzed benthic and intertidal samples collected during 1977 was carried out during 1984-85. Grab samples collected during 1974 and 1975 also were re-analyzed in 1984-85 for biomass determinations. With the exception of these differences in analysis times, all sample sorting procedures were consistent and were as follows.

Subtidal samples

All samples were preserved in 5-10% formalin in seawater. In the laboratory, samples were rinsed in fresh water through 1 mm screens and sorted with the aid of a dissecting microscope. All taxa but tanaidaceans, nebaliaceans, nemerteans, sipunculids and ostracods were identified to species level whenever possible. In some cases, species identification was precluded by the condition of the animals (e.g., most maldanid polychaetes were fragmented). Taxa which are generally smaller than 1 mm (e.g., foraminifera, all copepods) occurred in some samples, but were not included in any calculations.

Unidentified or tentatively identified species were sent to appropriate authorities for identification or verification (see ACKNOWLEDGMENTS). In cases where verifications indicated that additional taxonomic effort was required on previously sorted samples, the taxa in question were re-examined. In cases where it is generally recognized that additional species descriptions or revisions of higher taxonomic levels are required, questionable species or genera were pooled at the next highest taxonomic level prior to analysis.

Individuals of each taxon were counted, and lengths of individuals of all bivalve species were measured to the nearest millimetre. Wet weights (biomass) were obtained on a Mettler PT200 balance to the nearest milligram after removing excess surface water by blotting on filter paper. Each species of bivalve was weighed separately, whereas group weights were determined for all other taxa (e.g., polychaetes, amphipods, and gastropods). Bivalve weights included the shell whereas polychaetes were weighed without their tubes. Rare or extremely small animals were not weighed.

Intertidal samples

All samples were preserved in ~10% formalin in seawater. Amphipods were identified, counted and weighed at species level (whenever possible), and amphipod lengths from the tip of the rostrum to the end of the telson were measured to the nearest millimetre. Amphipods of the genus Onisimus were not identified to species if <6 mm long. The wet weight of each species or group in each sample was obtained by gently blotting dry and weighing on a Mettler PT200 balance to the nearest milligram.

DATA ANALYSIS PROCEDURES

Field and laboratory data were coded on data sheets, keypunched onto 9-track tapes, and processed using an IBM 3033/N12 computer. Data were key-verified and then checked against original data or checked with validation programs developed by LGL. Other LGL programs were used to generate tabulations used to select species for further analyses, and to organize the data into a format acceptable to packaged statistical programs. Analyses were performed using the SAS and BMDP computer program packages (Ray 1982; Dixon 1981).

Species assemblages were identified with the BMDP4M factor analysis program (Dixon 1981). Before factoring, a logarithmic transformation was applied to density data (log $[no \cdot m^{-2}+1]$) in order to reduce the skewness inherent in such data. The correlation matrix of transformed species abundances was calculated, principal components were extracted from this matrix, and factors were generated by Varimax rotation. Nine factors were considered (nine principal components had eigenvalues >1); these nine factors accounted for 63% of the variance among the 39 species variables. Each factor represents a group of species that tended to occur together.

A measure of the abundance of each species assemblage in a particular sample was obtained by calculating the corresponding factor score. A factor score is a linear additive function of the original variables, with each variable weighted in proportion to its correlation with the factor. A high factor score indicates that the group of species represented by the factor is common in the sample in question, and a low or negative factor score indicates that those species are rare or absent.

Two-dimensional polar ordination (Gauch 1982) was used to depict the similarities and differences among areas and depths. The Euclidean distance between each pair of depth/area combinations (25 areas and 3 depth ranges per area) was calculated, using as variables the mean factor scores produced in factor analysis. Depth/area combinations that differed maximally in Euclidean distance were selected as end points for the x-axis; the x-axis represented differences in depth. Thus the depth/area combination selected for one end of the x-axis was characterized by animal assemblages (high factor scores) typical of shallow water, whereas the depth/area combination selected for the other end was characterized by animal assemblages typical of deeper water. For each depth/area combination, position along the x-axis was computed geometrically based on the Euclidean distances from the depth/area combinations used as end points (Gauch 1982). Similarly, the y-axis was structured to represent differences in substrate. The depth/area combinations selected as the two end points for the y-axis were characterized by assemblages associated with fine substrates and coarser, heterogeneous substrates, respectively. This ordination was implemented on an Apple II+ microcomputer during this project.

Stepwise multiple regression analysis, BMDP2R (Dixon 1981), was used to assess the relationships between environmental variables and the density of intertidal animals. Locations were coded as "dummy" variables with a value of 0 or 1. The stepwise technique added envi-

ronmental variables to the regression equation one at a time, beginning with the variable having the strongest simple correlation with animal density. Environmental variables were then added in decreasing order of partial correlation until no additional variable would, if included in the equation, significantly (nominal $P<0.05$) improve the equation's ability to predict animal abundance.

As often happens, some environmental variables were significantly correlated with others. In the "stepwise" technique, the variable most closely correlated with abundance enters the equation first. In most cases the other related variable then becomes statistically non-significant because it is of little additional value as a predictor. In such circumstances it is usually not possible to determine which of the intercorrelated predictors is of direct importance to the animals.

RESULTS AND DISCUSSION

STUDY AREA

All of the study area lies within the Arctic marine zoogeographic province and includes eastern Lancaster Sound, the northeast coast of Baffin Island and the central Arctic archipelago (Fig. 1). Physical and chemical characteristics of the 23 sites that were sampled are presented in Tables 2 and 3.

The sites had several features in common. In most cases, intertidal substrates were composed of rock, cobble and pebble with little sand. Conspicuous algae such as Fucus spp., and animals such as limpets and barnacles, were absent. From the shoreline to depths of 2-3 m or more, substrates were generally sand with scattered rock. The seabed was often covered with filamentous algae and clumps of Fucus. Sessile infauna was scarce or absent and the most conspicuous animals observed were free-swimming amphipods. The seaward extent of this 'barren' zone was marked by the appearance of the Laminariales (kelp), bivalve siphons, fan worms, other infauna and epifaunal animals on the rocks. Substrates tended to become finer with increasing depth (Table 2).

Sampling sites included open coastlines, estuaries, semienclosed bays, and open bays. The Philpots Island, Cape Fanshawe, Possession Bay, Phoenix Head Glacier, Navy Board Inlet, and Scott Inlet sampling sites were all on the open coastline adjacent to northern Baffin Bay. The 50 m contour at these sites was located 0.5-2 km offshore and most study sites were 10-25 km wide (1 km at Cape Fanshawe and Possession Bay).

The sampling sites at Eclipse Sound, Byam Martin Island, Richardson Point, Graham Moore Bay and Bellot Strait were also located on open coastlines but faced the relatively narrow channels of the central archipelago. The 50 m contour was generally within 1 km of shore and the study sites were 1-1.5 km wide.

The sampling sites at Brooman Peninsula, Little Cornwallis Island, Cape Hatt and the outer portion of Creswell Bay were located in open bays that were not constricted at their openings. Rivers and streams emptied into the sea at or near all of these sites. Sampling sites were 1-2 km wide except in outer Creswell Bay where sampling extended over 10 km.

Cunningham Inlet, inner Creswell Bay, Bridport Inlet, and Brentford Bay all had a constricted opening to the sea and were well protected from the sea. Aston Bay is included in this group because of its shape (Fig. 1). The sampling site in inner Creswell Bay extended over 5 km and sampling was conducted throughout Cunningham Inlet. Sampling sites in the other bays covered about 1 km of shoreline. Rivers discharged into all of these bays.

Temperatures in the upper 5 m were as high as 4.3°C (Table 3). Low surface temperatures were due to the presence of nearby fast ice at Bellot Strait and Little Cornwallis Island, and the effect of a storm at Scott Inlet. Mean temperatures at the 21-55 m depth range were all below 0°C.

The study bays at Cape Hatt were the only areas not subject to the effects of ice during the sampling periods. Fast ice was present near sampling sites in Bellot Strait and Little Cornwallis Island. Large quantities of pan ice were present along the shorelines at Cape Fanshawe and Possession Bay. Wave induced motion of the ice caused disturbance of bottom sediments to depths of 3-5 m. Varying quantities of pan ice were found at all other sites during the sampling periods.

INFAUNA

A total of 460 quantitative infaunal samples taken at depths of 1-55 m in the central and eastern Arctic islands are discussed in the following sections. Additional samples taken at depths of 56-500 m in the eastern Arctic (Thomson 1982) and Barrow Strait (Table 1) are mentioned briefly for comparative purposes.

The animals considered in the following discussion are those that live within the substrate or are closely associated with the substrate. Tubicolous amphipods and amphipods living within the the surface layers of the sediment are included, as are ostracods and cumaceans. Tanaidacea, decapods, free swimming amphipods, foraminifera, nematodes, fish and mysids are not included.

Sampling efficiency

Some bias undoubtedly was introduced by the use of five different sampling devices (see Table 1). The pressure wave that precedes a descending grab sampler can cause loss of organisms. The airlift samplers were not prone to this problem. We have no estimate of the magnitude of this type of sampling error. A second and potentially more serious type of error is the depth to which different samplers penetrate the substrate. Because different samplers were

used in different locations in the present study, this type of sampling error may have been confounded with other types of differences among locations. For most samples, depth of penetration was estimated from the amount of substrate retrieved. Hence, we are able to evaluate the magnitude of this source of error. Depth of penetration apparently had a much greater effect on the accuracy of biomass estimates than of density estimates. Some samples included in the present study were from the BIOS study at Cape Hatt, Eclipse Sound, where an airlift sampler was used to penetrate the substrate to a depth sufficient to collect all visible organisms. For those samples, mean penetration depths in the four study bays ranged from 7.6 to 10.5 cm at 3 m depth, and from 12.0 to 14.5 cm at 7 m depth (n = 24 in each case; Cross et al. 1984). Preliminary studies at Cape Hatt showed the potential effect of penetration depth on density and biomass estimates (Table 4).

Density may have been estimated adequately by samples taken in the upper 3-5 cm of substrate, whereas accurate biomass estimates may have required penetration to 15 or 20 cm. Visual inspection by divers showed that the large animals were collected in the upper 15-20 cm of substrate. Most of the biomass in deeper strata (>5 cm) was attributable to large, deeply-burrowing individuals (mean individual weight 18.3 g) of the bivalve Mya truncata, although these large individuals contributed little to total infaunal numbers. Because most individuals of M. truncata were small individuals (mean individual weight 0.8 g) living in shallow strata, the density of this species was adequately represented in the shallow samples. In Bridport Inlet, Melville Island, a comparison of biomass estimates based on shallow (2-3 cm) airlift samples and on photographs of Mya truncata siphons (Buchanan et al. 1977) showed that the former method underestimated infaunal biomass by as much as 80-90% on some transects. However, the large M. truncata enumerated in photographs (estimated individual weight 20 g) contributed only 0.2-2.7% of total infaunal density estimates based on airlift samples. Thus, density of animals is adequately represented by samplers with a shallow depth of penetration, whereas biomass is not.

In the present study, penetration depths of grab samples at locations where penetration was estimated are shown in Table 5. Considerable variability was evident in penetration depths, both among locations and among depth ranges. Data presented above for Cape Hatt indicate that penetration likely was sufficient for adequate estimates of infaunal densities in most locations: mean penetration was >3 cm at 18 of 40 location/depth combinations, and was >2 cm in 28 of 40 cases. The airlift sampler used in Lancaster Sound and Baffin Bay (see Table 1) penetrated to approximately 5 cm at all locations. We have no data on penetration depths for the smaller Ponar grab (0.02 m^2) used at Cunningham Inlet and Creswell Bay. There was no evidence, however, that penetration of the larger Ponar grab (0.05 m^2) differed from that of the Van Veen grab (0.13 m^2): for the Ponar and Van Veen grabs, respective mean penetration depths for all samples in the 6-55 m depth range (the Van Veen grab was not used at depths <5 m) were 3.1 ± SD 2.4 cm (n=97) and 3.0 ± 1.9 cm (n=24).

The data presented above indicate a reasonable degree of comparability among types of sampling equipment and, at most locations, reasonable accuracy in estimating infaunal densities. The results presented below, however, should be interpreted with caution, particularly at those locations or depths where penetration was very shallow. Infaunal biomass, on the other hand, was adequately estimated only at Cape Hatt, where divers ensured that the airlift sampled all visible organisms. Therefore, the following analyses are based on density data, and biomass is discussed only briefly.

Density and biomass

Mean biomass and density of total infauna at each of the study sites are given in Table 6. With the exception of several very low density values, particularly in the shallow depth range, the study sites were remarkably similar with respect to infaunal density. Biomass data, on the other hand, varied markedly from one location to another (Table 6). Such variability is typical of several other Arctic locations, and the biomasses reported herein generally fell within the range of, or tended to be somewhat higher than, infaunal biomasses reported elsewhere (Table 7).

The highest biomass values reported (Table 7) are a result of (1) efficient sampling of deeply-burrowing infauna, (2) the collection of a few large individuals of species that were rare, patchily distributed, or both, or (3) sampling in areas where one or more species of bivalve was abundant in the surface layers of the substrate. The highest mean biomass estimate recorded in any of our studies (2267 $g \cdot m^{-2}$ from Cape Hatt in Eclipse Sound; Cross et al. 1984) was attributable to a combination of these three situations. Dominant species with respect to biomass were the deeply-burrowing bivalve Mya truncata (1121 $g \cdot m^{-2}$), the large and sparsely distributed bivalves Serripes groenlandicus and Hiatella arctica (361 and 127 $g \cdot m^{-2}$), and the abundant and relatively evenly distributed bivalve Astarte borealis (317 $g \cdot m^{-2}$; Cross et al. 1984). Biomass values of 1482 $g \cdot m^{-2}$ in Northwest Greenland (Vibe 1939) and 689 $g \cdot m^{-2}$ in Barrow Strait (present study) are examples of the second situation, and may be artifacts of the relatively small sample sizes in those areas (n=6 and 4, respectively). Relatively few individuals of S. groenlandicus and H. arctica contributed 1148 $g \cdot m^{-2}$ to the former estimate, whereas one large urchin (Strongylocentrotus droebachiensis) contributed 550 $g \cdot m^{-2}$ to the latter estimate. Finally, high biomasses in Lancaster Sound/Baffin Bay and in Viscount Melville Sound (876 and 585 $g \cdot m^{-2}$; Tables 6 and 7) likely represent accurate estimates of the standing stocks of abundant, evenly distributed bivalves in surface sediments. Dominant species in the two locations, respectively, were Macoma calcarea (499 $g \cdot m^{-2}$) and Astarte borealis (451 $g \cdot m^{-2}$), which occurred in all or most of the samples collected (6 of 6 and 7 of 8, respectively).

Bivalves accounted for 74% of biomass of all animals collected. Echinoderms and polychaetes accounted for 10% and 6%, respectively, of total biomass.

Taxonomic composition

In terms of animal density, polychaetes, bivalves, amphipods, ostracods and cumaceans were the dominant animals collected (Table 8). Relative abundance of amphipods was usually greatest at the shallowest depth range sampled. Bivalves were most abundant at depths of 6-55 m. Relative abundance of polychaetes was usually highest at the shallowest depth range (Table 8).

The most common species in each major taxon, and their contributions to mean density in all samples, were ostracods (15%), the cumaceans Diastylis spp. (10%) and Lamprops fuscata (3%), the amphipods Paroediceros lynceus (4%) and Protomedia fasciata (2%), cirratulid polychaetes (4%), spionid polychaetes (3%), the polychaete Pholoe minuta (3%), bivalves of the family Thyasiridae (4%), the bivalves Astarte borealis (2%), Astarte montagui (2%), Portlandia arctica (2%) and Macoma calcarea (2%), and the echinoderms Myriotrochus rinkii (1%) and Ophiura robusta (1%).

Community composition

Benthic ecologists, especially those working in northern seas, have traditionally attempted to classify benthic animals into communities. Each community is dominated by a few species of animals, and a given community type is expected to recur under similar environmental conditions within a marine zoogeographical area. Each community is traditionally given the name of one or two of the dominant species. In addition to those dominant species, certain indicator species that help to characterize the community should also be present. These animals are defined, ideally, on the basis of being unique to the community and abundant and conspicuous within it. The composition of a community can vary somewhat, with different indicator species occurring within a community under differing circumstances. When this occurs, different 'zones' are said to occur within the community. Thus, some animal species may always be present within a particular community, while other species may be present or absent depending on environmental conditions.

This classical approach to benthic community studies was summarized by Thorson (1957). Ellis (1960) used this approach in his description of the benthic marine communities of the Canadian Arctic. The existence of discrete and specific communities in particular physical circumstances would, if correct, provide a valuable basis for impact evaluation. However, in recent years the definitions, ecological significance and universal applicability of discrete benthic communities have been questioned and are being reevaluated (Mills 1969; Curtis 1975). Much of this criticism has arisen from the failure of recently applied statistical methods to confirm the results of early descriptive work (e.g. Stephenson et al. 1971). Many of the recent studies of benthic communities have incorporated multivariate statistical techniques, especially factor and cluster analysis.

Before one attempts to describe benthic communities of an area, several decisions must be made about the type of analysis to be performed, the type of data to be used, and the interpretation to be placed on the results (i.e. how ecological units are to be defined and described). For the purposes of this study, an acceptable definition of a benthic community would be that of Mills (1969): 'community means a group of organisms occurring in a particular environment, presumably interacting with each other and with the environment, and separable by means of ecological survey from other groups'. This definition has been left purposefully 'loose' by its author in order to leave the ecologist free to 'investigate biological relationships without unwarranted supposition' (Mills 1969). It also leaves the choice of methods required to achieve this end in the hands of the investigator.

In this study, we assumed that certain species of animals would tend to occur in association with one another, and that the abundance of these groups of species would vary with environmental conditions found in different parts of the study area. The first step in our analyses was to identify recurring groups of species; the second step was to identify the environmental conditions in which each such group tended to occur. Factor analysis and polar ordination were chosen as the respective methods for the two steps of the analysis.

Factor analysis to identify species associations: Assemblages of species that tended to occur together were identified with factor analysis (see DATA ANALYSIS PROCEDURES). The factor analysis was based on 318 samples from 18 locations (water depths 1-55 m). Samples from some of these locations were further grouped into geographic subdivisions. For example, the inner semienclosed portion of Creswell Bay was differentiated from the outer open portion of the bay. In order to make sampling effort more equitable among sites, only six of 24 samples from each depth/bay combination at Cape Hatt, Baffin Island, were considered; they were selected at random.

The analysis considered the 39 most common taxa, which together accounted for approximately 80% of the total density of infaunal animals collected. The nine factors (assemblages) produced by the analysis accounted for 63% of the variance in densities of these 39 taxa. Table 9 shows the taxa whose densities were strongly correlated with each factor. The taxa that were strongly correlated with each factor tended to be found together in samples. Thus each of these factors represents an assemblage of animals that were found together.

A measure of the abundance of each assemblage was calculated for each sample (see DATA ANALYSIS PROCEDURES). The mean abundance of each assemblage for various depth/area combinations is shown in Fig. 2. High values on this figure indicate that the species represented by

the assemblage were common in samples taken in that depth/area combination. Low or negative values indicate that those species were rare or absent.

The first assemblage, representing Macoma calcarea, Mya truncata, Astarte spp. and 13 other species, was characteristic of samples taken in NW Baffin Bay, Lancaster Sound and Eclipse Sound. It was rare or absent at depths <5 m in Eclipse Sound and at <20 m off Philpots Island and Cape Fanshawe. This assemblage was relatively rare in samples from the central Arctic islands. Standing crop in samples from Cape Hatt at 7 m depth had a high abundance of this assemblage and was extremely high, typically 1 $kg \cdot m^{-2}$ or more (Table 10).

The second assemblage, representing two species of Astarte, a maldanid polychaete, sabellid polychaetes and ostracods, was found throughout the study area, but not at all sites. It was most common in Eclipse Sound and sites in Viscount Melville Sound. It was common at the two shallowest depth ranges in Eclipse Sound and the two deepest ranges in Viscount Melville Sound. Total biomass at locations where this assemblage was prominent (and other assemblages were not prominent) ranged from 100 to 400 $g \cdot m^{-2}$.

The third assemblage, representing various polychaetes, was not restricted in its depth or geographic distribution (Fig. 2). However, it was most abundant in protected bays.

The fourth assemblage, representing the holothurian Myriotrochus rinkii, gastropods and other species, was most common at Cape Hatt, Baffin Island, and at a few other sites throughout the study area at the two shallowest depth ranges.

The fifth assemblage, representing amphipods, a cumacean and two polychaete species, was characteristic of the two shallowest depth ranges in all regions of the study area.

The sixth and seventh assemblages were characteristic of deeper depths. The assemblage including Maldane sarsi, Nuculana minuta and other species was most abundant in Eclipse Sound and the central Arctic islands, and the assemblage representing Owenia fusiformis, Diastylis spp. and other species was most abundant in the Lancaster Sound and Baffin Bay region.

The eighth assemblage, representing the bivalve Portlandia arctica and cirratulid polychaetes, was found mainly at sites in the central Arctic islands. Typical standing crop biomass in samples where this assemblage was prominent was 100-400 $g \cdot m^{-2}$ (Table 8).

The ninth assemblage, representing the amphipod Protomedia, was found at all depth ranges and appeared unrestricted in its geographic distribution.

Ordination of sites: The purpose of ordination as carried out in this study was to identify patterns in the presence of infaunal assemblages among the different sampling sites. These patterns are discussed below and are followed by discussions of potential environmental determinants of these patterns.

Two dimensional polar ordination was used to "arrange samples in the two dimensional space such that similar entities are close by and dissimilar entities are far apart" (Gauch 1982). Similarity and dissimilarity were assessed on the basis of animal assemblages present in the depth/area combinations used in the factor analysis (Fig. 2). Similarity is expressed as physical distance on the plot of the results (Fig. 3).

Previous work in the Canadian high Arctic (Thomson 1982) showed that depth and substrate were critical determinants of benthic community composition. Therefore, we structured the analysis to stress depth and substrate differences (see DATA ANALYSIS PROCEDURES).

End points of the x-axis were selected such that this axis represented depth differences in the animal assemblages present. The 0-5 m depth range off Philpots Island (the shallow end of the x axis) was characterized by the crustacean assemblage and to lesser extent the polychaete and Protomedia assemblages (Fig. 2). At the deep end of the x-axis are depth/area combinations characterized by the Maldane/Nuculana and Owenia/Diastylis assemblages. Consequently, depth/area combinations with animal assemblages typical of shallow depths are at the left of the plot, and those representing deep depths tend to be at the right (Fig. 3). The kinds of animals present at each depth/area combination determined the locations on the graph, so the shallow, intermediate and deep cases are not totally separate on the graph.

End points of the y-axis were selected such that this axis represented substrate differences. The deepest depth in Aston Bay showed a high abundance of the assemblage representing the bivalve Portlandia arctica, a species that is most abundant in areas with a fine silt substrate (Table 8; Ellis 1960). This depth/area combination therefore represented fine substrates, and other depth/area combinations that showed a high abundance of the same assemblage are located close to it on the plot (centre bottom, Fig. 3). These depth/area combinations had substrates composed primarily of silt and clay (Table 2). The intermediate depth at Cape Hatt sites was characterized by coarser heterogeneous substrates (Table 10) and formed the other end of the y-axis (centre top). Depth/area combinations located close to the top of the plot contained coarser heterogeneous substrates (Tables 2 and 10).

To illustrate how the depth/area combinations are arranged on the ordination plot, Fig. 4 shows abundances of characteristic assemblages at depth/area combinations that lay close to the centre of each axis ($x = 0$, $y = 0$) arranged according to their positions along the other axis. Along the y (substrate) dimension, the abundance of the Portlandia assemblage is high at depth/area combinations with fine substrates but declines toward the centre of the y-axis (Fig. 4). In contrast the abundances of the

Macoma and Astarte assemblages increase near the centre of the y-axis and are high for coarse, heterogeneous substrates. Along the x (depth) dimension the abundance of the shallow water crustacean assemblage declines toward the centre of the plot, and the abundances of the deeper water Maldane/Nuculana and Owenia/Diastylis assemblages increase (Fig. 4). Depth/area combinations found toward the ends of axes on the ordination plot (Fig. 3) contain assemblages that are similar to each other.

Depth/area combinations located at the centre of the ordination plot (Fig. 3) either had animal assemblages characteristic of more than one axis end point (deep, shallow, fine, coarse) or were not dominated by any one assemblage. These depth/area combinations were thus roughly equidistant from all end points and could not be characterized on the basis of animal assemblages present. For example, the 6-20 m depth range off Philpots Island had an abundance of the generally shallow water crustacean assemblage and of the deeper water Owenia/Diastylis assemblage (Fig. 2) and was located close to the centre of the plot on Fig. 3. The shallowest depth range at Richardson Point showed negative values for all assemblages (Fig. 2) and was also located close to the centre of the plot.

The ordination of sites (Fig. 3) shows that some depth/area combinations had similar assemblages. These similarities may be due to similarity of substrate, depth or other environmental factors. Some of the environmental determinants that could affect community composition are discussed below. However, more than one assemblage may be dominant at any one site and various combinations of assemblages are dominant at various sites (Fig. 2). On the basis of animals present, most sites cannot be categorized as falling within any one distinct group of sites (Fig. 3). These results indicate that the distribution of the infauna is far more complex than can be explained in terms of classical community concepts (Thorson 1957; Ellis 1960). There appears to be a continuum of assemblages based on depth, substrate and other environmental factors. Other important determinants of animal distributions could be exposure, food supply, salinity and temporal variability. Some of these environmental determinants are interrelated. For example, a discussion of depth effects on distributions of shallow water animals must also include consideration of exposure.

Factors affecting distribution

Depth: We found that the extent of the barren zone was somewhat variable. In the central part of the Arctic archipelago and Eclipse Sound, it appeared to extend to a depth of 3-5 m. Biomass was generally low in the 0-5 m depth range and highest in the 6-20 m depth range (Table 6, 11). In Lancaster Sound and NW Baffin Bay, low biomass (Table 6) and high abundance of amphipods (Table 8; see INTERTIDAL HABITAT) indicate that the barren zone extended to depths of 10-20 m. This extension of the barren zone was reflected in the ordination of depth/area combinations (Fig. 3 and 4). The animal assemblages in the 6-20 m depth range from Philpots Island and Phoenix Head Glacier, when ordinated, were close to the shallow end of the x-axis. In contrast, many shallow depth ranges from locations in the central archipelago and Eclipse Sound were found toward the centre of the plot, indicating that these depth/area combinations had animal assemblages characteristic of deeper depths.

Maximum average biomass was found at depths of 6-20 m in Eclipse Sound and Barrow Strait, and at depths of 56-105 m in NW Baffin Bay and Lancaster Sound (Table 11). Beyond the depth of maximum biomass, there was a progressive decrease in biomass with increasing depth to the maximum depths sampled (400-500 m) in Eclipse Sound, northwest Baffin Bay and Lancaster Sound, and 269 m in Barrow Strait. This trend is a general feature of the world's oceans; increasing vertical distance from food supply appears to be the factor responsible (see Rowe et al. 1974). Most primary production occurs in the upper 50 or 60 m of the water column and benthic animals, even at the greatest depths, depend upon this production for most of their food.

Differences in the depth of maximum biomass among areas may be related to exposure and food supply (see below).

A variety of factors combine to make shallow Arctic waters (<20 m) an unsuitable habitat for many benthic invertebrates. Variable salinity, ice scour, fluctuations in temperature, and an ice-foot extending from the beach to a depth of 2 or 3 m present formidable obstacles to the establishment of infaunal species in very shallow water (Ellis 1960). The ice-foot as well as the other types of perturbations may persist all year. The shallow water bivalves Macoma calcarea and Astarte borealis, echinoderms and most polychaetes are all rather intolerant of brackish water (Ushakov 1955; Ockelmann 1958; Petersen 1978). Infaunal animals were scarce in shallow water at most sites and these depths were inhabited mainly by mobile species. Chief among the mobile species in shallow water are amphipods, especially Onisimus litoralis and Gammarus setosus. Distribution and ecology of these species are discussed below (see INTERTIDAL HABITAT).

Exposure: A wave exposure index was calculated for each sampling site (see MATERIALS AND METHODS). Sites exposed to Baffin Bay were differentiated from sites in the Arctic islands that had a similar high exposure index but were open to the relatively narrow channels of the archipelago. Exposure appeared to have considerable effects on the depth distributions of benthic animals. At the most exposed eastern Arctic sites, total density and biomass, and density of echinoderms, increased with increasing depth (Fig. 5). These trends were less evident at sites in the central Arctic islands. Differences in depth distribution of echinoderms and infaunal amphipods were particularly interesting. Echinoderms were absent in the shallowest depth ranges (<5 m) of the exposed sites but a few were present at the most protected sites. In contrast, infaunal amphipods were most abun-

dant at the shallow and intermediate depth ranges at exposed eastern Arctic sites. These animals are capable of leaving their tubes and swimming about. The benthic environment at the most exposed sites in the eastern Arctic appears to be relatively hostile down to depths of 5-20 m. At protected and exposed sites within channels the barren zone extends to depths of 5 m or less.

Substrate: In Lancaster Sound, Eclipse Sound and NW Baffin Bay, Thomson (1982) found that there was a significant correlation between depth and substrate. The finest substrates were found in deep water and the coarsest in shallow water. Changes in substrate with increasing depth are most rapid in shallow water. At Cape Hatt, Eclipse Sound, sediments are finer at 7 m than at 3 m (Cross et al. 1984). This trend is also evident at sites in the central Arctic islands (Table 2). Some of the relationships between depth and species composition (Fig. 2 and 3) may actually result from substrate effects.

Six assemblages were abundant at depths >5 m. The assemblage representing Myriotrochus rinkii and other species was nowhere dominant and was not included in the following discussion. Substrate differences among areas may, in part, account for differences in the abundances of the other five benthic assemblages among areas.

The Portlandia assemblage was found only in areas that had substrates composed of silt and clay (Table 10). The Macoma and Astarte assemblages were found in coarser heterogeneous substrates (Table 10). The Owenia/Diastylis assemblage reached maximum abundance in substrates that were slightly coarser and less heterogeneous (sorting coefficient was smaller) than those associated with the Macoma assemblage. The Maldane/Nuculana assemblage was abundant in substrates that were finer than those associated with the Macoma assemblage (Table 10). At Cape Hatt, abundance of the Maldane/Nuculana assemblage was highest in the two bays with the highest percentage of clay (Fig. 2; Table 2). Fine sediments associated with a high abundance of the Maldane/Nuculana assemblage tended to contain sand. In most instances, substrates associated with a high abundance of the Portlandia assemblage did not contain sand (Table 10).

The Astarte assemblage may reach maximum densities in substrates that are less heterogeneous (sorting coefficient is smaller) than those associated with the Macoma assemblage and coarser than those associated with the Owenia/Diastylis assemblage (Table 10). Possible substrate associations of these assemblages are summarized below:

	Substrate	
	Coarse	Fine
Heterogeneous	Macoma, Maldane/Nuculana	Portlandia
Homogeneous	Astarte, Owenia/Diastylis	

The assemblages representing crustaceans and the amphipod Protomedia reached maximum abundance in coarse homogeneous substrates in shallow water (Table 10).

Examples of the effect of substrate on distributions of benthic animals in selected areas are shown in Fig. 6-8. In Bridport Inlet, the Mecham River appears to have considerable influence on the distribution of the infauna. The river presumably drops fine silt as it enters the inlet, with substrates becoming coarser as distance from the river increases. Diver-operated airlift sampling carried out at 3-15 m depth on seven transects spread over 12 km of shoreline showed that relative biomass of Portlandia arctica was highest off the river and decreased away from the river; the opposite was true for Astarte borealis (Fig. 6). Astarte borealis prefers heterogeneous substrates and, in the Lancaster Sound area, was most abundant in substrates of sand and coarse silt (Thomson and Cross 1980).

The Owenia/Diastylis assemblage was dominant at Possession Bay, Bylot Island. There was little variability in its abundance at depths of 15-50 m (Fig. 7). Substrates at these depths were homogeneous and showed little variability. Mean grain size was 3.30 ± SD 0.36 and sorting coefficient was 1.16 ± SD 0.59 (n=13). No infauna at all was found at the 5 m depth at this site and this assemblage was found in two of three samples at 10 m.

The abundance of the Portlandia assemblage did not show much variability in Cunningham Inlet (Fig. 8). Substrates there were also homogeneous, being composed of silt or silty clay.

Substrate appears to be one determinant of community composition. High densities of some assemblages were associated with substrates that were quite different from those associated with high densities of other assemblages. However, more than one assemblage was present in many depth/area combinations (Fig. 2), indicating that some substrate conditions were tolerable for several assemblages. The depth/area combinations that are close together on the ordination plot (Fig. 3) may have differed minimally or not at all in substrate. Since a broad spectrum of substrates was sampled, there was a broad spectrum of combinations of animal assemblages in the samples. These combinations of assemblages appeared to form a continuum as illustrated in Fig. 4, top.

Predation and mortality: Green et al. (University of Western Ontario, London, ON, unpublished data) have calculated growth rates and age at length for three species of bivalve molluscs from Cape Hatt. They estimate annual average mortality rates of 8% for Mya truncata and from 7 to 11% for Astarte borealis. Green et al.'s age distributions for Macoma calcarea were unstable at ages <10 yr and mortality could not be estimated. This instability appears to be a common feature of Macoma calcarea age/length/frequency distributions. Stoker (1978) found Macoma calcarea age distributions from the Bering Sea to be unstable at lengths of <10-15

mm. Our size data from Phoenix Head Glacier, with ages calculated using data from Green et al. (University of Western Ontario, London, ON, unpublished data), indicate a similar situation:

Length (mm)	8-11	12-16	17-20	21-25	26-30
Age (yr)	2-5	6-10	11-15	16-20	21-25
Number	86	166	210	75	10

At ages >10 years, mortality was about 7% per year at Cape Hatt and about 10% per year off Phoenix Head Glacier.

Mortality rates of bivalves in the Bering Sea (Stoker 1978) are substantially higher than those reported here. Stoker (1978) estimates average annual mortality of Macoma calcarea to be about 31.5% per year. In West Greenland, Petersen (1978) estimates mortality of Macoma calcarea to be about 20-60% depending on location. He estimates mortality of Mya truncata to be about 10-25% depending on location. In temperate waters mortality of bivalves can be as high as 65% over a two month period (Rachor and Salzwedel 1975).

Animals tended to be smaller in shallow water than in deep water. At Cape Hatt, mean lengths of three of five bivalve species and of a holothurian were greater at 7 m than at 3 m (Cross and Thomson 1981). Similarly, at the Phoenix Head Glacier mean length of Macoma calcarea increased with depth:

Depth (m)	22	65	100
Mean length (mm) ± SD	16 ± 4	19 ± 5	21 ± 5
Number measured	483	133	65

Mean lengths of Astarte borealis in Eclipse Sound also increased with increasing depth:

Depth (m)	5	10	15	22
Mean length (mm) ± SD	11 ± 5	14 ± 7	17 ± 8	23 ± 13
Number measured	13	65	96	12

These differences in mean length were presumably due to differential rates of mortality at different depths. The differences may be caused by the more rigorous physical environment in shallow water and lower predation rates in deeper water.

Occasional environmental perturbations resulting in mortality of the shallow water infauna could account for the smaller average sizes in shallow depths. Because these species grow very slowly, about 1 mm·yr^{-1} at Cape Hatt, Green et al. (University of Western Ontario, London, ON, unpublished data), mortality of bivalves in shallow water could occur infrequently and still account for the observed variability in length distributions. We observed mass mortality of Arctic shallow water animals in Aston Bay, Somerset Island, in 1977, and at Cape Hatt, Baffin Island, in 1980 and 1981. Divers observed dead animals, especially echinoderms, to a depth of 5 or 6 m along the 25 m of shoreline surveyed in Aston Bay and in all bays at Cape Hatt. Input of fresh water during spring runoff and ice melt may cause mortality of animals in shallow water if this freshened layer becomes thick enough. Benthos along shorelines exposed to NW Baffin Bay may be affected by severe storms. Off NE Bylot Island, the action of 3 m swells on pan ice was observed to stir up the bottom to a water depth of at least 5 m. Most infaunal animals would not have survived this kind of perturbation. Indeed, no infauna was present at 0-5 m depth at the Cape Fanshawe and Possession Bay sites on Bylot Island (Table 4). In temperate waters, recovery of the shallow water infauna from a major catastrophe may take up to a decade (Yeo and Risk 1979). Given the low growth rates in the Arctic, recovery could be even slower there.

Within most parts of the study area, predation by marine mammals is not a major influence on the benthos. Walruses summer at Little Cornwallis Island, Brooman Point, Lancaster Sound and a few other areas, but are not numerous. Bearded seals also feed on benthos (Finley and Evans 1983) but are only sparsely distributed throughout the study area. White whales occasionally feed on benthic animals but fish are the preferred prey (Kleinenberg et al. 1964). White whales do not feed when in rivers and estuaries in summer. Hundreds of white whales summer in Cunningham Inlet but the standing crop of infaunal benthos does not appear much affected (in Table 6, compare Cunningham Inlet with Aston Bay and Bridport Inlet, areas with similar fauna). In contrast, marine mammals are important consumers of benthic animals in the Bering Sea. Walruses consume about 20% of bivalve standing crop annually and gray whales consume about 5% of total benthic standing crop (Fay et al. 1977; Thomson and Martin 1983). About 300 000 benthic-feeding bearded seals are also present in the Bering Sea.

Benthic fish may be important predators on the infauna. A recent diving study (M. Fabijan, LGL Ltd., King City, ON, unpublished data) has shown that these fish may be considerably more abundant than previously believed. These fish tend to hide under rocks and in burrows where they would not be sampled by conventional means. Other predators include gastropods, carnivorous polychaetes and starfish. The low mortality rates of Arctic bivalves, at least below the depth of the barren zone, indicate a low rate of predation. With the exception of areas near walrus haul-out sites, it is unlikely that predation rates upon the high Arctic infauna will vary among locations.

Low mortality rates of benthic animals result in a long life span and a large mean age for the population as a whole. At Cape Hatt, mean lengths of Macoma calcarea correspond to mean ages of 7-10 years; for Astarte borealis, mean age ranges from 13.8 to 15.9 years. Mean age of Macoma calcarea from 20 m depth off the Phoenix Head Glacier was about 12 years. In general, long life spans of the high Arctic benthos indicate a low rate of turnover in the population, little disturbance, and a relatively static community structure.

Feeding and food supply: The infaunal animals collected by the grab and airlift samplers were classified into four feeding guilds and, separately, three motility classes, based on the literature. The feeding modes and motility classes follow those described by Fauchald and Jumars (1979). The density in each sample was apportioned among the four guilds and three classes of motility to provide a measure of abundance of each guild in each sample. The trophic relationships of the infauna are discussed below.

Filter feeders extract particulate material from the water. Sabellid polychaetes feed externally using a brachial 'fan', whereas bivalves pump water through their mantle cavity and remove particulate material with their gills. Mya truncata burrows deeply in the sediment and extends a siphon to the surface. Mussels (Musculus sp.) are usually attached to rocks or algae and filter material from water entering through a gape in their shell. Many benthic filter feeders ingest material of benthic rather than pelagic origin (Marshall 1970).

Some deposit feeders ingest sand or mud directly from the substrate. These include tube-dwellers (maldanid polychaetes) and polychaetes that burrow through the mud such as Capitella capitata (Fauchald and Jumars 1979). Deposit feeders derive their nutrition from bacteria associated with the organic matter and detritus found in the sediments. The deposit feeders generally feed at some depth below the surface of the sediment. The activity of these animals is especially important in reworking the surface layers of the sediment (e.g. Cadée 1979).

Surface deposit feeders feed at the sediment-water interface. Their food includes benthic microalgae and bacteria. Most of the polychaetes included in this group feed by means of tentacles (Fauchald and Jumars 1979). The bivalve Nuculana minuta extends a pair of tentacles over the surface of the sediment (Ansell and Parulekar 1978); the bivalve Macoma calcarea draws in fine particulate material from the sediment surface with an inhalant siphon (Reid and Reid 1969).

All the carnivores are motile predators. Many of the errant polychaetes, priapulids and nemerteans are carnivores.

The dominant mode of feeding for high Arctic benthic animals from the study area was surface deposit feeding (Table 12). Filter feeding was the next most common mode of feeding (Table 12). However, surface and below surface deposit feeders together were much more numerous than filter feeders in all areas (Table 12).

Filter feeders were more abundant in exposed areas than in bays (Table 12), probably because filter feeders depend on currents to bring their supply of food (Ölscher and Fedra 1977).

Most benthic animals in the study area are motile, at least to some degree. Sedentary animals were least numerous within bays and inlets, where fully motile animals were dominant. A typical high Arctic benthic animal would be a fully motile surface deposit feeder.

Much of the primary productivity that occurs in Arctic waters appears in a short early summer pulse, and sinks unutilized to the sea floor (Longhurst et al. 1984). This unused productivity forms the major food supply for benthic animals. The prevalence of a surface deposit mode of feeding may be an adaptation to this pulsed productivity. Thomson and Martin (1983) also found surface deposit feeding to be the dominant feeding mode by benthos in the northern Bering Sea, where productivity is also pulsed. The unused productivity, and associated bacterial flora and decomposition products, are available to surface deposit feeders throughout the year. Primary productivity in the study area is low (Subba Rao and Platt 1984), so the supply of material sinking to the sea floor must be rather low. Most animals in our samples are capable of some form of motility. Foraging for food must be a necessity.

FOOD SUPPLY: Primary production by marine phytoplankton, benthic macroalgae and microalgae forms the primary food source for benthic animals. This material may be used directly, but detritus derived from this material is also a major food source for benthic animals. The following paragraphs estimate the amount of primary production available to benthic animals in our study area.

Benthic macroalgae was found in trawls or observed by divers at virtually all sites that were sampled. Kelp was found wherever rock substrate formed a suitable site for attachment. Most macroalgal biomass was due to the Laminariales, especially Agarum cribrosum, Alaria grandifolia, Laminaria solidungula and other species of Laminaria. Thomson and Cross (1980) and Cross et al. (1984) provide some algal biomass values for the area of interest (Table 13).

There are no measurements of productivity of macroalgae from our study area. However, in the Alaskan Beaufort Sea, Dunton et al. (1982) found a productivity to biomass ratio of 0.95 for Laminaria solidungula. Application of this productivity to biomass ratio to a total macroalgal biomass of 1 $kg \cdot m^{-2}$ yields an annual productivity of about 43 g $C \cdot m^{-2}$ (dry wt = 15% wet weight, carbon = 30% dry wt). Chapman and Lindley (1980, 1981) estimated that the same species produced about 20 g $C \cdot m^{-2} \cdot yr^{-1}$ in Foxe Basin. Few animals feed directly on this kelp and most of the plants' productivity enters the food chain as dissolved organic matter or fragments that form a substrate for microbial colonization (Miller and Mann 1973; Stuart et al. 1981; Dunton et al. 1982).

Using data from Harrison et al. (1982), Subba Rao and Platt (1984) estimated pelagic primary productivity of the eastern Arctic to be about 27 g $C \cdot m^{-2} \cdot yr^{-1}$. However, this estimate is based on September sampling only and may be too low. During a September sampling period, Harrison et al. (1982) reported chlorophyll a concentrations of 57 $mg \cdot m^{-2}$. This value is

considerably lower than the 80, 70 and 75 mg Chl a$\cdot m^{-2}$ found by Sekerak et al. (1979) for the 23 July-18 Aug, 19 Aug-17 Sept, and 18 Sept-10 Oct periods, respectively, in Lancaster Sound and Baffin Bay (Table 11). In spring, chlorophyll a concentrations in Wellington Channel, which flows into Lancaster Sound, were 3-5 mg$\cdot m^{-3}$ in the upper 25 m (Bain et al. 1977) or about 100 mg$\cdot m^{-2}$. Harrison et al. (1982) have calculated productivity rates of 6.7 g C$\cdot$g Chl $a^{-1}\cdot d^{-1}$ for all Arctic waters and 4.0 for Baffin Bay. Using the lower figure and a mean chlorophyll concentration of 100 mg$\cdot m^{-2}$ during a 20-d spring bloom and 75 mg$\cdot m^{-2}$ during the remaining 100-d growing season, productivity would be about 38 g $C\cdot m^{-2}\cdot yr^{-1}$. Productivity of the ice algae at Cape Hatt, Baffin Island, measured in situ by divers, reached a maximum of 2.5 mg $C\cdot m^{-2}\cdot h^{-1}$ at the end of May. Assuming a 40-d season, total productivity by ice algae would be only 2.4 g $C\cdot m^{-2}\cdot yr^{-1}$. In Resolute Bay, Welch and Kalff (1975) estimated the productivity of benthic microalgae to be about 15 g $C\cdot m^{-2}\cdot yr^{-1}$. As previously mentioned, most of the pelagic primary productivity may sink to the bottom unused by the zooplankton. The phytoplankton that is consumed by zooplankton is available to the benthos as fecal pellets.

All sources considered, and assuming that half of the macroalgal production is exported from nearshore areas as dissolved organic matter or detritus, a total of approximately 80 g $C\cdot m^{-2}\cdot yr^{-1}$ may be available to the shallow water benthos in the Baffin Bay and Lancaster Sound region.

There are undoubtedly regional differences in primary productivity. Chlorophyll a concentrations were much higher in the eastern Arctic, including Eclipse Sound and Cape Hatt, and in channels of the central archipelago (80-100 mg Chl a$\cdot m^{-2}$) than in bays and inlets of the central Arctic islands (7-60 mg$\cdot m^{-2}$) (Tables 3 and 14). Summertime chlorophyll a concentrations in the southeastern Beaufort Sea were less than 20 mg$\cdot m^{-2}$ in the upper 20 m (Grainger 1975).

Overall, at open exposed locations not covered by ice, a high standing crop of phytoplankton may be maintained from early June until late August or, in the case of Lancaster Sound, even into late September. Annual variations in ice cover probably play a significant role in determining total annual productivity. Standing crop of chlorophyll under the ice is very low (Table 14).

Vertical stratification of the water column, shallow depths, and the short wind fetch in shallow semienclosed bays may prevent nutrient replenishment of surface waters. The higher integrated nitrate values in open areas (Table 14) may indicate that currents and winds enhance vertical mixing and lead to higher standing crop.

In Bridport Inlet, Aston Bay, Brentford Bay, outer Creswell Bay and Cunningham Inlet, surface nitrate values were higher at stations near rivers than at stations in the middle of the bay (Sekerak et al. 1976; Buchanan et al. 1977; Thomson et al. 1978; LGL Ltd., King City, ON, unpublished data). Riverine input of nutrients may account for some of the higher integrated chlorophyll a values for semienclosed bays and inlets listed in Table 14. Higher primary productivity in an area would lead to higher productivity of the benthos, and because of general low mortality rates, high standing crop.

Secondary productivity of the infauna

The productivity of three species of bivalve at 7 m depth in three bays sampled at Cape Hatt, Baffin Island, in 1980 is summarized in Table 15. Productivity was estimated in the following manner. Growth rates determined by Green et al. (University of Western Ontario, London, ON, unpublished data) were applied to the observed length frequencies of the 677 individual Mya truncata, 1774 Astarte borealis and 567 Macoma calcarea measured by Cross and Thomson (1981). The shell length vs dry meat relationships (Cross and Thomson 1981) were then used to determine the annual increase in biomass for each 1 mm length group and summed for the population. Recruitment has been ignored, but productivity by these small individuals would be small. Productivity in the form of reproductive products was also ignored.

These three bivalve species accounted for 72.2% of the biomass of all infauna at the 7 m depth at Cape Hatt. All bivalves represented 93.4% of biomass. These productivity estimates would, therefore, be representative of the productivity of the infauna as a whole.

Productivity to biomass ratios of bivalves were extremely low, 0.11-0.18, when compared to values of 1.5-4 recorded for bivalves in temperate seas (cf. Burke and Mann 1974; Rachor and Salzwedel 1975; Rachor 1977). There was little variation among species or among the three bays, which were close to each other. In the Bering Sea, Stoker (1978) estimated a productivity to biomass (P:B) ratio of 0.32, but he believed that he underestimated productivity. At a shallow sheltered location in Greenland, Peterson (1978) estimated a P:B ratio of 0.35 for filter feeders (86% of biomass) and 0.10 for deposit feeders. At a shallow exposed location the value was 0.21 for filter feeders.

Although the P:B ratios in our study area were low, the total productivity of the three species was moderately high when compared to other areas. In the very productive northern Bering Sea, Thomson and Martin (1983) estimated total benthic productivity to be about 23 g $C\cdot m^{-2}\cdot yr^{-1}$ (about 60 g dry wt$\cdot m^{-2}$). Petersen and Curtis (1980) estimated productivity to be 289 g wet wt$\cdot m^{-2}\cdot yr^{-1}$ (about 45 g dry weight) at Godhavn, Greenland. In the North Sea, benthic productivity is about 48 g$\cdot m^{-2}\cdot yr^{-1}$ dry weight (Crisp 1975).

Mean annual productivity of the three bivalve species studied at Cape Hatt, pooled, was about 15.7 g$\cdot m^{-2}$ dry wt (about 4 g $C\cdot m^{-2}$). Applying these rates to all bivalves would yield a productivity of about 5 g $C\cdot m^{-2}\cdot yr^{-1}$. Assuming a gross growth efficiency of 15%, about 33 g $C\cdot m^{-2}\cdot yr^{-1}$ of primary production would be

required to sustain the benthic productivity. This figure is approximately equivalent to pelagic primary productivity and about half of the total amount of plant material produced.

The high biomass of the Arctic infauna is maintained by its moderately high productivity, which results from a moderate flux of phytoplankton and macroalgal material to the benthos, and by a low rate of predation. The productivity to biomass ratio is low and approximately equivalent to the mortality rate (about 10%). Below the depth of the barren zone, it may be hypothesized that an equilibrium exists between primary productivity and standing crop of benthos. Most of the organic input is used for maintenance and relatively little for production. Benthic infaunal communities in the high Arctic appear to be characterized by low mortality, high biomass, low productivity to biomass ratio, and a preponderance of old individuals and may, therefore, represent the climax condition.

FAUNA OF ROCK SUBSTRATES

Exposed bedrock, boulders and soft substrates overlain with a cobble veneer were sampled in some areas. We have insufficient information to compare and contrast the fauna of rock substrate among areas. However, the non-quantitative grabs in cobble substrates, diver observations, hand collections from exposed bedrock and vertical rock surfaces, and a few quantitative airlift samples on exposed bedrock are sufficient to characterize the fauna of high Arctic rock substrates.

A lush growth of kelp and other seaweeds was often found on subtidal rock surfaces. Many animals that were observed and sampled may have been associated with the seaweed rather than the rock per se.

Cobble substrates

Fauna associated with cobble substrates included barnacles, gastropods, chitons, the rock bivalve Hiatella arctica, ophiuroids, sea urchins, starfish and spirorbid polychaetes (Table 16). The cobble was often covered with crustose coraline algae and bryozoans. The brachiopod Hemithyris psittacea was occasionally found attached to the rock. Infaunal bivalves, polychaetes and sandy-silt mud were also found in the grab samples. The presence of live animals and plants on the cobble indicated that it formed a veneer over soft substrates.

Exposed bedrock

A few quantitative samples were taken on exposed bedrock or boulders. At Cape Fanshawe, Baffin Island, biomasses at 5 and 10 m depths were 20 $g \cdot m^{-2}$ and 253 $g \cdot m^{-2}$ wet weight (Table 17). Echinoderms, anemones, the rock bivalve Hiatella arctica and mussels were the dominant animals (Table 17). At 20 m off Phoenix Head Glacier, one boulder was found to have 800 $g \cdot m^{-2}$ of epifauna that included sponges, hydroids, barnacles and tunicates.

Large conspicuous sessile animals that were observed on rock surfaces in the Lancaster Sound region, Eclipse Sound and Clarke Fiord included the following:

- Barnacles: Balanus balanus, B. balanoides, B. crenatus
- Bivalves: Musculus discors, Crenella faba, Hiatella arctica
- Sea Cucumbers: Psolus sp.
- Polychaetes: Spirorbis sp.
- Tunicates: Ascidia callosa, Boltenia echinata, Styela rustica
- Anemones, hydroids, sponges, bryozoans.

Large conspicuous motile animals that were observed on rock surfaces in these regions included the following:

- Chitons: Tonicella marmorea, T. rubra, Lophyrochiton albus
- Gastropods: Buccinum spp., Margarites sp.
- Starfish: Leptasterias polaris, Solaster papposus, Stephanasterias albula, Henricia sp.
- Ophiuroides: Ophiura robusta, Ophiopus arcticus, Ophiacantha bidentata, Ophiocten sericeum
- Echinoids: Strongylocentrotus droebachiensis.

Amphipods and errant polychaetes were also observed on rock surfaces. Animals often associated with the kelp that grew on rocks were caprellid amphipods, nudibranchs, mysids and decapods (other than crangonids). Spirorbid polychaetes were often observed growing on filamentous algae.

Barnacles, mussels, spirorbid polychaetes, the bivalve Hiatella arctica, tunicates and sponges are all filter feeders. Their abundance and distribution would be determined by the amount of phytoplankton in the water, the length of the phytoplankton growing season, and the amount of particulate material brought by the currents.

Chitons and some gastropods are grazers of algae on rocks and would be more abundant in areas that provided large amounts of this material. Distributions of starfish and urchins are discussed below.

EPIBENTHOS

Large animals such as starfish and sea urchins and fast swimmers such as decapods and mysids were found over both mud and rock substrates. They were not adequately sampled with the grab and airlift. These animals were sampled with an Otter trawl and by divers. Kelp was often taken in trawl samples and kelp on the bottom may have caused the trawl to sample over the seaweed rather than over the bottom. Urchins, decapods and ophiuroids were the most common animals sampled with the Otter trawl. Other animals taken in the trawls included pycnogonids, especially Nymphon hirtipes, the large isopod Mesidotea sabini, soft corals, anemones and tunicates (Table 18).

Echinoderms

The sea urchin Strongylocentrotus droebachiensis was taken in Otter trawls at most sites that were sampled (Table 18). Large numbers were taken in trawls off Phoenix Head Glacier, Eclipse Sound, Allen Bay and Little Cornwallis Island. Biomass of urchins may reach 200-400 $g \cdot m^{-2}$ and density may reach 14 $indiv \cdot m^{-2}$ (Table 19). Urchins consume seaweed, detritus and small plants (Miller and Mann 1973) and availability of this material may be a major determinant of their distribution. Of the six areas for which quantitative estimates were available, density of urchins was lowest in Bridport Inlet. Kelp was scarce in Bridport Inlet and found only in a few rock outcrops. Biomass of algae was high at the other locations (see Feeding and food supply).

The crinoid Heliometra glacialis was taken in trawls at depths of 21-55 m off the Phoenix Head Glacier and in Eclipse Sound and at depths of 6-55 m only off the river in Bridport Inlet. It was observed by divers off a river mouth in Brentford Bay at depths of 20 m and was taken in gillnets set at a depth of 6.5 m off a river in inner Creswell Bay. Most of our specimens were taken off river mouths or off glaciers.

Starfish, primarily Urasterias lincki, and the ophiuroid Ophiocten sericeum were most common in samples from Bridport Inlet. The seabed at Bridport Inlet was flat and devoid of rocks and kelp. This was the only location at which the trawl may have consistently sampled on the bottom.

Decapods

Decapods were most common in trawl samples from Little Cornwallis Island, Brentford Bay, and Bridport Inlet. Crangonids (mudshrimp) and Lebbeus spp. were dominant at locations where decapods were most common (Table 20). Divers often observed shrimp, including Lebbeus polaris and L. groenlandicus, in association with kelp. Kelp and Lebbeus spp. were common in trawls from Little Cornwallis Island and Brentford Bay but both were rare in trawls from Bridport Inlet. Crangonids were the most common decapods in Bridport Inlet.

Mysids

The littoral mysids Mysis litoralis and M. oculata are common in nearshore areas. Dense shoals of mysids have been observed in shallow nearshore areas of Brentford Bay, Navy Board Inlet, Scott Inlet and at Cape Hatt. In Freeman's Cove, dense shoals of mysids were observed being preyed upon by ringed seals (K.J. Finley, LGL Ltd., Sidney, BC, personal communication). At depths greater than 5 m, divers found mysids concentrated close to the bottom and under fronds of kelp. In addition to seals, littoral mysids are preyed upon by Arctic char, Arctic cod and a variety of seabirds (Bradstreet 1976; Sekerak et al. 1976; Bain and Sekerak 1978; Craig et al. 1984).

In Brentford Bay, Boothia Peninsula, there appeared to be segregation of species and size classes by depth (Table 21). Young of both mysid species were found in shoals in very shallow water. Mean size of Mysis litoralis was larger at 5 m depth and large individuals of M. oculata were found at depths of 20 and 30 m under the fronds of kelp. This type of depth distribution for these two species also has been noted in Alaska (Holmquist 1958).

Amphipods

The most common subtidal amphipod species collected, in decreasing order of abundance, were Paroediceros lynceus, Guernea sp., Protomedia fasciata, Corophium sp., Onisimus litoralis, Atylus carinatus, Pontoporeia femorata, Monoculodes spp. and Orchomene minuta. Together the species accounted for 49% of all amphipods collected. The remaining species individually accounted for less than 2% of the total numbers collected. Epibenthic amphipods that spend most of their time in the water column swimming over the bottom include lysianassids, calliopids, gammarids and pleustids. Density estimates of epibenthic amphipods are not as accurate as those for infauna, because of escape of organisms from the area sampled and inclusion of those inadvertently drawn into the grab or airlift from outside the sampling area. No quantitative estimates are available for the extent to which epibenthic amphipods were over- or underestimated in the present study.

In the subtidal area, density of epibenthic amphipods was highest at depths of 5 m or less, but the ratio of epibenthic amphipods to total amphipods was similar for all depths sampled (Table 22). Some of the differences in density of epibenthic amphipods among sites may have been due to differences in exposure. Exposed sites that were open to Baffin Bay had the highest densities of epibenthic amphipods; sites in the central archipelago had the lowest densities (Table 23).

At Cape Fanshawe and Possession Bay, epibenthic amphipods were the only animals collected by grab at depth 5 m. Epibenthic amphipods were relatively scarce at Cape Hatt, where only the two shallowest depth ranges were sampled. Excluding the Cape Hatt samples, there was a decrease in density of epibenthic amphipods with increasing depth (Table 22).

Gammarus setosus, an intertidal species, was also found in the subtidal habitat at many locations (Table 24). Highest numbers in the subtidal were found at the 0-5 m depth range off Cape Fanshawe and Possession Bay, where the intertidal zone was covered with ice and inaccessible to amphipods. Off Phoenix Head Glacier, G. setosus was also present in high numbers at this depth range. At all but one location, densities were higher in the intertidal habitat than in the subtidal.

Onisimus litoralis, which was common in the intertidal region, was frequently abundant to depths of 5 m (Table 24); its abundance decreased with depth. Unlike Gammarus setosus, densities of Onisimus litoralis were often higher in the subtidal than in the intertidal zone (Table 24). Densities of O. glacialis and

O. nanseni were higher in the intertidal than the subtidal (Table 24). At depths of 0-5 m, densities of Onisimus spp. were highest off Phoenix Head Glacier, Brooman Peninsula, Richardson Point and Graham Moore Bay. Subtidal substrates at these locations and depths were mainly sand (Table 2). The association between Onisimus spp. and sand is discussed below (INTERTIDAL HABITAT).

Decapods, mysids and amphipods were the most commonly encountered epibenthic animals. They form an important component in the diets of Arctic char, seabirds and ringed seals. Very little information is available about the environmental factors that determine the abundance and distribution of these animals. Feeding habits of the common decapods mentioned above appear to be similar (Squires 1968). We have no information on feeding habits of the mysids. In deeper water (>5 m), mysids (Mysis spp.) and decapods (Hippolytidae; Lebbeus spp.) appear to be associated with kelp. Shoaling habits of mysids and factors governing the distribution of mysid shoals in the study area are unknown.

INTERTIDAL HABITAT

Through much of the high Arctic, the intertidal zone is composed of cobble and pebbles with some areas of sand, mud, and exposed bedrock or boulders. For most of the year, fast-ice is anchored to the shore to a depth of 2 m or more, and occupies virtually the entire intertidal zone. In summer, varying quantities of pan ice may be present in the intertidal zone. As a result of tidal and current action, these pans abrade the shoreline and, through melting, reduce the surface salinity. Temperatures may reach 9°C on warm, calm days, but fall abruptly to 0°C on windy days or in the presence of ice. Salinity of water at the shoreline is also affected by snow melt and the presence of numerous small streams, many of which are ephemeral.

The above factors combine to make the intertidal zone uninhabitable to sessile epifauna, infauna, and most algae (Ellis and Wilce 1961; Lee 1973). Consequently, the high Arctic intertidal zone is generally regarded as barren and devoid of life (Stephenson and Stephenson 1972). Although marine life typical of temperate shores is found in the Arctic, e.g., barnacles of the genus Balanus and the alga Fucus vesiculosus, the establishment of these species in the intertidal zone is usually precluded by the harsh and variable environmental conditions. Fucus spp. is often found in the subtidal barren zone.

The only animals consistently encountered on these shores are mobile amphipods, especially Onisimus litoralis and Gammarus setosus (Sekerak et al. 1976; Thomson et al. 1978). Both are tolerant of low salinities and fluctuating low temperatures (Dunbar 1954; Steele and Steele 1970). In spring, these species predominate on the undersurface of landfast ice and graze on the dense growth of ice-associated microalgae (Cross and Martin 1983). Intertidal areas are sometimes important feeding areas for vertebrates because of the presence of these intertidal amphipods and tide stranded zooplankton. The importance of G. setosus and O. litoralis in the diets of marine birds and fish is discussed in Alliston et al. (1976), Sekerak et al. (1976), Bradstreet (1977) and Bain and Sekerak (1978).

Intertidal site descriptions

From 1977 to 1981, a total of 234 quantitative samples were collected from the intertidal zones of 16 sites in the eastern and central Canadian Arctic (Table 1; Fig. 1). Data on the physical environment, including temperature, salinity and substrate composition, are summarized for low, mid and high tide levels at each location in Table 25.

Intertidal sampling was conducted mainly in semienclosed bays and open coast areas. Wave exposure indices, after Baardseth (1970), ranged from 3 to 81 units (Table 2). All locations except the sampling site at Philpots Island were slightly influenced by fresh water, usually from seasonal rivers (Table 3).

Intertidal zones were free of pack ice at the time of sampling, with the exception of Byam Martin Island, the most exposed area. The intertidal zone at Byam Martin Island was protected by vast quantities of grounded ice that acted as a breakwater for the shore. Although the intertidal zone was protected from wave action and was greatly influenced by an inflow of fresh water, temperatures and salinities at the sampling stations were similar to those at other locations.

Water temperatures at the tidal interface ranged from -0.4 to 8.9°C. In some areas, temperature fluctuated greatly with tide level; lower temperatures were usually recorded at or near high tide (Table 25). Salinities ranged from 7.7 to 29.4 and, with few exceptions, remained relatively constant during the tidal cycle. Because most locations were sampled on only one day, we have no estimate of temporal variability in temperature or salinity at most locations. However, in Brentford Bay, considerable differences in temperature and salinity were evident at the same stations sampled only 3 d apart. Thus some of the apparent differences among locations may represent temporal variability.

Intertidal substrates at most sites were mainly cobble and pebble (Table 25). However, substrates at all four locations sampled in the Viscount Melville Sound area (Byam Martin Island, Graham Moore Bay, Bridport Inlet and Richardson Point) were almost entirely sand, or sand with silt and clay. In addition, these four locations were also characterized by a more gently sloping beach than at other locations. Substrate type at Brooman Peninsula was similar to that in the Viscount Melville Sound area (i.e. sand), but the slope of the beach was steeper than at any other area.

Abundance and biomass of amphipods

At all locations, high density and biomass values were due to the presence of large numbers of Gammarus setosus, Onisimus spp., or both (Table 26). Both density and biomass of amphipods were consistently lower at high tide levels (ranges of 0-185 indiv$\cdot m^{-2}$ and 0.01-5.72 g$\cdot m^{-2}$) than at low tide levels (ranges of 43-2856 indiv$\cdot m^{-2}$ and 0.38-22.22 g$\cdot m^{-2}$). This difference suggests that amphipods move up the intertidal zone with the rising tide, becoming less concentrated as they spread out over the intertidal zone.

Amphipod distribution was relatively even on a small scale in the intertidal habitat at some locations (e.g. most standard deviations < means at Eclipse Sound, Little Cornwallis Island). At other sampling sites, however, numbers and biomass were extremely variable, even between samples collected several metres apart (e.g. Allen Bay; 12-6640 indiv$\cdot m^{-2}$ and 0.03-61.45 g$\cdot m^{-2}$). This wide range of variability in amphipod abundance within a small area may, in part, be attributable to the mobility and behaviour of the amphipods. Lysianassid amphipods (e.g. Onisimus spp.) generally have a well-developed sense of chemoreception and are frequently found in large concentrations (Busdosh et al. 1982). Small-scale differences in abiotic variables along a shoreline may also affect amphipod distribution and these are discussed below.

Large-scale variation in amphipod density (i.e. between locations) was also evident. Values ranged from 3-1905 indiv$\cdot m^{-2}$ when all tide levels were combined (Table 27). Relatively low densities (<100 indiv$\cdot m^{-2}$) were found more frequently in the eastern locations. Only one location in the central Arctic had a mean density <100 indiv$\cdot m^{-2}$; low numbers were collected in Bridport Inlet, an area with a silt and clay substrate. Byam Martin Island and Brooman Peninsula harbored the most amphipods. It is uncertain, however, whether the apparent differences in total density of amphipods between eastern and central Arctic locations were real or attributable to temporal variation. All eastern locations were sampled in 1978 or 1981, whereas central locations were sampled in 1977. Environmental differences and differences in time of sampling among sites may also account for differences in density. These considerations are addressed below.

Species composition

At least 16 species of gammarid amphipods were found in the intertidal habitat of our study sites (Fig. 9). Twelve of these were rare, usually contributing <2% toward total amphipod density in each location. Gammarus setosus and the genus Onisimus together accounted for >93% of total density at all locations.

Gammarus setosus was the most abundant species in intertidal samples. It constituted up to 98% of total amphipod numbers. It was found at all locations except Navy Board Inlet, where only nine amphipods were collected in 13 samples. G. setosus is found primarily in the intertidal and in shallow water during the open-water season (Ellis and Wilce 1961; Steele and Steele 1970).

Three species of the genus Onisimus were found at the tidal interface: O. litoralis, O. glacialis and O. nanseni. Onisimus litoralis has been described as one of the only occupants of sandy beaches in Arctic regions (Steele 1961). However, this species was the dominant amphipod at only two of our sampling locations (Philpots Island, Navy Board Inlet); intertidal substrates at these locations were mostly bedrock and boulder, or rock and cobble with some patches of sand. This species was, however, the most important species of Onisimus at all the eastern locations and in Brentford Bay.

Onisimus glacialis was the most important species of Onisimus in the Viscount Melville Sound area and in a few other central Arctic locations. Onisimus nanseni was usually collected in very low numbers. However, at Little Cornwallis Island it contributed 32.4% of amphipod numbers. Unidentified Onisimus juveniles (<6 mm) were also abundant at many locations in the central Arctic. Onisimus glacialis has been previously collected in large numbers in the brackish shallow waters of a lagoon in the Beaufort Sea (Griffiths and Dillinger 1981). However, O. glacialis is reportedly pelagic and also occurs on the undersurface of fast ice and on the sides of pan ice in summer (Stephensen 1935; Sekerak et al. 1976; Cross 1982). Onisimus nanseni is also generally considered to be pelagic (Stephensen 1935). In previous studies, very few juveniles (<6 mm) have been collected during August and September (Steele 1961; Cross and Martin 1983).

The data suggest that Gammarus setosus and Onisimus litoralis are the most common amphipods of the eastern Arctic in summer. However, in August 1982 at Cape Hatt, Baffin Island, O. glacialis was as abundant as O. litoralis (Cross and Martin 1983). This change in species composition may be partly attributable to temporal variability.

Only single specimens of Boeckosimus affinis, Atylus carinatus and Anonyx sarsi were collected in the intertidal zones. Atylus carinatus and Anonyx sarsi, together with amphipods from the families Oedicerotidae, Stenothoidae, Calliopiidae and Pleustidae, were more common in shallow sublittoral than in intertidal habitats at our study sites. Boeckosimus affinis has been reported previously in sandy beaches (Steele 1961) and may be a true intertidal species (Dunbar 1954). Gammaracanthus loricatus may also exclusively inhabit intertidal areas during the ice-free season, but numbers collected at any time were low. Gammarus wilkitzkii and hyperiid amphipods are usually pelagic.

Other taxa including larvaceans, pteropods and copepods were also collected in intertidal habitat (Buchanan et al. 1977; Thomson et al. 1978; Thomson and Cross 1980). These pelagic animals are brought in by currents and tide and, therefore, are not considered here. Because the sampling method was designed to collect motile

amphipods, the few infaunal animals collected (i.e. nemerteans and polychaetes) were not considered.

Amphipod life cycles

Amphipods, like many other Arctic crustaceans, do not have pelagic larval stages, but brood eggs and larvae, and release the young as fully developed individuals (Steele 1961). Thus juveniles are largely recruited from local populations. In the event of a major disturbance of a large area, recolonization by invertebrates with direct development will be slow (Chia 1970). Environmental stress may also affect one stage of development but not become apparent until a later stage (Rosenthal and Alderdice 1976). Consequently, the population structure of intertidal organisms in Arctic areas may be an important indicator of pollution of various types. In this section, we present length-frequency data for the amphipod species Gammarus setosus and the dominant species of Onisimus.

Arctic Gammarus setosus have an annual reproductive cycle, breeding in autumn and releasing their young in spring or early summer (Steele 1961; Steele and Steele 1970). Their annual reproductive cycle is presumed to be associated with the spring algal bloom (Dunbar 1968; Steele and Steele 1970).

Population structure was polymodal at most of our sampling areas (Fig. 10), with peaks representing true year classes (0+, 1+ and 2+ year classes). Measurements of specimens from Cape Hatt in spring 1981 and 1982 (C. Martin, LGL Ltd., King City, ON, unpublished data) showed that young were released in spring and early summer at a length of 3 mm. By August and September young-of-the-year averaged 4-5 mm in length (Table 28). Thus, the release of juveniles must have occurred at about the same time throughout our study area, irrespective of location or year of sampling.

Mean lengths of the larger cohorts (the 1+ and 2+ year classes) varied among locations (Table 28). Immature Gammarus setosus (1+ year old) were relatively small at Phoenix Head Glacier, Aston Bay and Brentford Bay; growth was only about 3-4 mm in one year (Table 28). In contrast, a growth rate of 8 mm was estimated for the first year at Eclipse Sound where one year olds averaged 12 mm long in September. Growth rates of G. setosus collected at Cape Hatt were similar to those at Eclipse Sound. These differences in growth by Gammarus setosus may be caused by differences in food abundance or other local factors.

Most Gammarus setosus in our samples were small (3-5 mm; Fig. 10). Newly released individuals accounted for almost all G. setosus caught at some locations (e.g. Byam Martin Island, Graham Moore Bay and Bellot Strait). Collections of G. setosus from the coast of Labrador also consisted mostly of juveniles (Steele 1961). Cross and Martin (1983) found high numbers of juveniles compared to cohorts of larger individuals.

Mean lengths of Gammarus setosus tended to increase with increasing amounts of rock and cobble (Fig. 11A). The three locations in the Viscount Melville Sound area had a sandy intertidal zone and few large individuals (Fig. 10).

Large Gammarus setosus frequently are found under rocks at low tide (Steele 1961). Consequently, small individuals might constitute an especially high proportion of the animals at the water interface at low tide. However, no strong trend was found (Fig. 11B).

At Eclipse Sound and Cape Hatt, where growth was rapid and amphipods 1+ years old were large, we found few larger (age 2+) individuals. In contrast, the 2+ year class was very abundant at Phoenix Head Glacier, Aston Bay and Brentford Bay, where growth rates were relatively slow (Fig. 10). Predation by Arctic char may have caused these differences. Arctic char are found in Eclipse Sound, including the Cape Hatt area. Arctic char feed in the intertidal zone at high water and consume Gammarus setosus (Sekerak et al. 1976). Through their feeding activities, char may reduce population levels, and intraspecific competition, and thereby allow faster growth. Biomass of G. setosus was higher in Aston Bay, Brentford Bay and Phoenix Head Glacier, areas where char are rare or absent, than in Eclipse Sound and Cape Hatt (Table 27). Abundance of rock and cobble was not very different at these sites.

According to Steele (1961), Onisimus litoralis and O. glacialis require two years to reach maturity, mate in the fall or winter, and die after releasing their young in spring. A bimodal size distribution is typical for this genus, with peaks representing true year classes (0+ and 1+ year class). However, at many of our sampling locations there were two peaks for the 0+ year class (Fig. 12). Juveniles released in spring should have reached about 8 mm in length by August and September (Steele 1961; Cross and Martin 1983). However, individuals of 3-5 mm long also were abundant at many of our sampling locations. A 6-9 mm size class was also present for all species of Onisimus. It appears either that juveniles were released during spring and also later in the season, or that different species released young at different times.

The 0+ year class predominated at most locations. However, age 1+ Onisimus litoralis were the most important year class of this species at both Brentford Bay and Bellot Strait, northern Boothia Peninsula.

Amphipods of the genus Onisimus are frequently collected from the shallow sublittoral. Size compositions of O. litoralis collected at 2 and 5-10 m depths along Phoenix Head Glacier and Navy Board Inlet are illustrated in Fig. 13. At these locations, small individuals tended to be found in the intertidal and larger individuals in the subtidal at depths of 2-10 m. Small specimens of O. litoralis found under the ice in Bridport Inlet in late spring had been feeding on phytoplankton (Buchanan et al. 1977). Larger specimens feed on carrion and zooplankton (MacGinitie 1955; Sekerak et al. 1976; Thomson et al. 1978). The concentrations of larger indivi-

duals in subtidal areas is perhaps attributable to higher food availability for scavengers in the subtidal.

Implications: Amphipod reproductive success depends on availability of food for the young. Timing of release of young coincides with seasonally optimum conditions, which are only present for a brief period (Dunbar 1968; Steele and Steele 1970). Changes in timing of release of young due to environmental stress may have latent effects on the reproductive cycle. Direct oiling of intertidal populations of Gammarus setosus during August 1981 caused a delay in the release of juveniles on the under-ice surface the following spring (Cross and Martin 1983). In August 1982, these newly released juveniles were reportedly reduced in size by 1 mm compared to the previous year. The implications of this reduced size on survival or fitness are not known.

Juvenile or larval stages of many marine organisms seem to be more sensitive to pollutants than are the adults (Moore and Dwyer 1974; Rice et al. 1975; Linden 1976; Wilson 1977). Linden (1976) found that at age 4-6 d and length 1 mm, Gammarus oceanicus were about 700 times more sensitive to crude oil than were adult G. oceanicus. Juvenile Onisimus litoralis also appeared to be more sensitive than adults to Prudhoe Bay crude oil (Foy 1982). During summer, when Onisimus and Gammarus juveniles are found in very high numbers in the intertidal, they would be vulnerable to accidental contamination by oil.

Factors influencing the abundance of intertidal amphipods

Intertidal animals are subject to greater environmental variations than are any other group of Arctic marine invertebrates. The two complete tidal oscillations each day entail fluctuations in water level and, in some circumstances, fluctuations in salinity, temperature and ice conditions. In addition, salinity varies with the presence of melting or forming ice, and with freshwater discharge. Temperature fluctuates with cloud cover, state of the tide, and time of day. The presence of potential food and habitat in the form of macrophytic algae is extremely variable.

In order to determine which environmental variables were important predictors of the abundance of various kinds of intertidal animals, multiple regression analyses (see DATA ANALYSIS PROCEDURES) were performed on the data from 202 quantitative samples from all locations shown in Table 25. In addition to tide, temperature and salinity, other variables used in the analyses were slope, substrate type and geographic location (Table 29). Samples for which any of these data were missing were not included. According to MacGinitie (1955), Onisimus litoralis feeds on tide-stranded zooplankton. The slope of the intertidal zone may be of importance in causing the stranding of zooplankton and thus in providing a food source for O. litoralis. Thomson et al. (1978) found that the abundances of Gammarus setosus and Onisimus litoralis may vary with the nature of the substrate, so substrate type was also considered.

Many of the environmental variables used in the analysis were significantly correlated with one another (Table 30). High water temperatures were associated with low tide levels, gently sloping beaches, sheltered areas, and low salinities. Some of the substrate type variables were negatively intercorrelated. Because the substrate values were percentage cover estimates, a high value for one type of substrate implied that the values for other substrates were low. An intertidal zone with gentle slope was associated with sand substrates, as in the Viscount Melville Sound area. When predictor variables are strongly intercorrelated, it is usually not possible to determine which of those variables is (or are) of direct importance to the animals.

Multiple regression equations accounted for approximately 42% of variance in total density of amphipods (Table 31). Tide accounted for more variance than did any other variable; high abundances tended to occur at low tide. High amphipod densities were also associated with high temperatures. Densities tended to be marginally lower on sandy shores. After these variables were taken into account, amphipod densities were relatively high in North Boothia Peninsula and relatively low in Eclipse Sound.

Substrate type and tide level accounted for most of the variance in the density of Gammarus setosus. This species was most abundant at low tide and on substrates with little sand and much rock (Fig. 14A). However, amounts of rock and sand were negatively interrelated (Table 30), as expected, and rock was not a significant predictor after sand was considered. After allowance for tide and substrate effects, high densities of this species were also associated with low salinities and low wave exposure. G. setosus was most abundant in the Viscount Melville Sound locations and least abundant in Barrow and Crozier Straits, after allowing for effects of physical variables.

Amphipods of the genus Onisimus were also most abundant at low tide but less abundant on rock and cobble substrates than on sand (Table 31; Fig. 14B,C). After allowing for other variables, total density of Onisimus amphipods was relatively high in North Boothia Peninsula and Barrow and Crozier Straits, and marginally lower than average in Eclipse Sound. Densities were also correlated with high temperatures and a gentle slope (Table 32), but tide level and percentage rock cover were the best predictors of densities.

Onisimus glacialis was associated with areas of high wave exposure, whereas Onisimus juveniles were more abundant in areas of low wave exposure. Wave exposure was correlated with temperature, substrate and location (Table 30) and, therefore, it is not known which intercorrelated variable is the causative influence. Densities were less closely related to environmental variables in the cases of O. litoralis and O. nanseni (30.9% and 26.9% of variance explained, respectively) than for the other taxa. This makes interpretation of the results for these species difficult.

Overall, the analyses indicate that the most common animals in the intertidal area reach their maximum density when the tide is low. In the strict sense, they are probably not true intertidal animals. It is the lack of suitable habitat that prevents these animals from remaining in the intertidal area above the water level. In the northwest Atlantic, Gammarus setosus is found under algae and rocks during low water (Steele and Steele 1970). Similarly, in Brentford Bay, Boothia Peninsula, Thomson et al. (1978) found G. setosus among Fucus and in other damp refuges on an intertidal island that was above water at low tide. The low abundance (on a per m^2 basis) at high tide may be due to the spreading out over the intertidal of the animals that are concentrated near the waterline at low tide.

The abundance of Gammarus setosus was negatively correlated with salinity. This species is euryhaline (Steele and Steele 1970), but we are unable to provide any definite explanation for the apparent association with water of lower salinity. Gammarus setosus was abundant off the Phoenix Head Glacier where the salinity in the intertidal was lowered by large amounts of glacial runoff.

Multiple regression analysis was moderately effective in explaining distributions of common intertidal amphipods. In all cases, geographic location was a significant predictor of density. This indicates that important environmental determinants may not have been included in the analysis. These could include predation and food availability in the form of diatoms, filamentous algae, tide stranded zooplankton and meiofauna. Some of these determinants may be site specific and may account for regional differences in density.

Results of this study indicate that ample food exists for vertebrates that forage in the intertidal and barren zones of most sites. Some of these vertebrate predators may include Arctic char, Arctic cod, sculpins, shorebirds, Arctic terns and some seabirds. Apart from the sculpins, these vertebrates are not found at most of the study sites. Arctic char are generally found within 30 or 40 km of their natal rivers (Johnson 1980) and this limits their marine distribution. The distribution of Arctic terns and seabirds is limited by the availability of breeding habitat. Shorebirds generally nest inland and forage in the intertidal only during migration. Arctic cod may also forage near shore in very large concentrations (Bain and Sekerak 1978); however, these large concentrations are not routinely encountered. As in the case of the infauna, it appears that predation on intertidal amphipods may also be quite low.

CONCLUSIONS AND IMPLICATIONS

Depth, substrate, predation, food supply and exposure appear to be major determinants of standing crop and community composition of the infauna of the central and eastern Arctic islands.

Because of ice scour and variations in temperature and salinity, depths from the intertidal to 3-5 m or more are only sparsely populated by the infauna. This sparsely populated barren zone extends to greater depths at exposed locations. A high standing crop is found at depths between 6 and 50 m.

The kinds of animals present within given depth ranges may be largely determined by the nature of the substrate. In some cases, animal assemblages from areas with similar depth, substrate and physiographic attributes appear to be similar. For the most part, there appears to be a continuum of animal assemblages among our study sites. Small differences in the abundance of animal assemblages between many pairs of sites account for the observed spectrum of community structures and these may be related to small environmental differences.

Beyond the depth of the barren zone, predation and mortality of the infauna appear to be at low levels. The benthos is therefore dominated by slow growing, large, old individuals. The productivity to biomass ratio is low and most of the energy available to the benthos is used for maintenance rather than growth. The low level of predation, low mortality, slow rate of growth and dominance by old individuals implies a static rather than a dynamic infaunal community. The evident community structure may therefore represent the climax condition and not one that is in transition. Under these conditions, biological interactions among species, including competition for space and food, must represent equilibrium conditions.

The feeding strategies of these benthic animals appear to be well adapted to a pulsed type of productivity regime. Most high Arctic benthic animals are motile surface deposit feeders. They are thus able to forage for food and feed on organic matter year-round. Macrophytic algae may be an important source of food for the shallow water benthos. Regional differences in standing crop and productivity of the macroalgae and phytoplankton may be an important determinant of standing crop of infaunal benthos.

The amphipods found in the intertidal zone are most abundant at low tide. Differences in abundance of the common species are related to substrate. Predation on these animals may also be quite low. Exposure, geographic location, temperature and salinity are also determinants of abundance.

The nearshore high Arctic benthos appears to be largely unexploited as a food resource for vertebrates. Harp seals, white whales, narwhals, bowhead whales and seabirds undertake long migrations and spend only a short period of time in the study area. These animals feed mainly on fish and zooplankton. Some seabirds consume littoral amphipods and mysids, but none of these migrants feed primarily on infauna. Walruses feed on benthic bivalves, but walruses are not numerous in the Canadian high Arctic.

The ringed seal, the most abundant species of marine mammal in the study area, feeds mainly

on fish and large zooplankters. However, ringed seals do consume mysids and littoral amphipods that inhabit the under-ice surface. Bearded seals feed on benthic animals, but are nowhere very numerous. Benthic fish may be more numerous than previously believed; however, their small size would preclude predation on the large old bivalves that form the bulk of infaunal biomass. In contrast, in some other marine areas demersal fish or marine mammals consume a high proportion of the standing crop every year. In the Bering Sea, walruses, gray whales and bearded seals are major predators of the infauna (Fay et al. 1977; Burns and Frost 1983; Thomson and Martin 1983).

The lack of exploitation of this abundant food resource is difficult to explain. It appears that the resource could support more benthic feeding vertebrates. Pelagic feeders do not appear to be hampered by Arctic conditions. Early and recent hunting of marine mammals does not appear to provide an explanation. LGL (1983) estimated that, in pre-whaling days, the bowhead whale was the major pelagic consumer in the eastern Arctic and that it now plays only a minor role. Walruses may have been much more numerous in pre-whaling days and could have consumed great quantities of benthos in parts of the study area. However, walruses concentrate in specific areas and show a great deal of site tenacity. Even with a much larger walrus population, the benthos in much of the study area would have remained unexploited.

Dunbar (1968) argues that growth and diversification of the Arctic fauna is in its infancy. Although there is a large flow of biological energy though the pelagic ecosystem, most of this flow goes through or terminates in only one predator, the Arctic cod (LGL 1983). Exclusive of Arctic cod, vertebrates, mainly ringed seals, directly consume less than 1% of zooplankton productivity (LGL 1983). The pelagic food chain is relatively simple when compared to other seas and suggests a state of infancy. It could be argued that a major benthic food chain has not yet evolved in the high Arctic.

The low level of predation with implied minimal disturbance and recolonization is probably a major factor in structuring infaunal communities. Very little of the benthos would be in transition from the disturbed to the climax state. Under these stable conditions, similar communities of animals should be found under similar conditions. This lack of natural disturbance should simplify studies that seek to establish relationships between community structure and environmental determinants.

RECOMMENDATIONS FOR FUTURE STUDIES

The results of this study show that depth, substrate, predation, food supply and exposure are important determinants of community structure. These topics should be addressed in the design of future studies of Arctic benthos. Little is known about the role of biological interactions in structuring Arctic infaunal communities. This type of information would be useful for impact prediction. Although predation on the benthos appears to be minimal, benthic resources that are used by vertebrates, such as nearshore amphipods and mysids and infauna in the vicinity of walrus haul-out sites, are important and should receive the highest priority for future studies. The following points are presented for consideration in the design of future Arctic benthic studies:

Studies of benthic communities

1. Sampling should be conducted along environmental gradients, rather than in discrete habitats or locations. We feel that an approach that examines gradual changes over distance rather than gross differences among areas will yield better information on the causal relationships between environmental determinants and community composition, and aid in identifying those determinants that are most important. An example would be to sample along the 20 m contour from the estuary of a river in a semienclosed bay through the bay to the exposed coastline. Changes in substrate and benthic community composition along this contour could then be examined without dealing with a depth effect.

2. Estimates of potential pelagic primary productivity in the form of nutrient and chlorophyll profiles, plus data on the standing crop of benthic algae, would be extremely useful in explaining differences in standing crop of benthic animals among areas.

3. Organic content of the sediment is related to grain size (Thomson 1982) and may not be a good indicator of food availability to detritivores. Assessments of food availability should include measurement of chlorophyll in sediments and some measurement of relative biomass of living organisms (bacteria, meiofauna). ATP content of sediment may be a useful measure (Wildish 1977).

4. Some estimate of population stability can be obtained even during a short sampling effort by measuring specimens of the dominant bivalve and estimating age at length. These data allow estimates of mortality and productivity to be made. Differences in mortality among areas could explain differences in community structure (i.e. between a static and a dynamic community).

5. Disturbance and recolonization studies would yield valuable information on the structuring of high Arctic benthic communities. A comparison of various stages in the succession process to actual measurements of community structure measured in the field would yield information on species interactions that affect the structure of observed communities.

6. The ecology of nearshore mysids, especially factors associated with shoaling behaviour in shallow water, should be investigated. Shoaling increases their availability to vertebrates.

7. Further taxonomic work on Arctic benthic animals is required. There is as yet no comprehensive treatment of the Canadian Arctic amphipods and polychaetes. Assessment of impact and determination of community structure may be limited by lack of relevant material for specific identifications.

Impact studies

The effect of industrial activities on the high Arctic benthos must be distinguished from natural temporal and spatial variability. The study design and analysis techniques used in the BIOS experimental oil spill project were selected to distinguish impact from natural variability. However, in actual impact situations, pre-impact sampling may not be possible and the impact site may not be known in advance. Determination of impact under these circumstances will be difficult. Studies of population stability and recolonization following disturbance, and sampling along environmental gradients, would assist in the selection of control sites and the determination of impact. Specific studies that could be conducted before industrial impacts occur in order to facilitate detection of later impacts include:

1. The determination of sample sizes required to show a fixed percentage of mortality in various habitat types.

2. Investigation of the possibility of using bivalve growth lines to determine growth rates prior to impact for comparison with after impact rates in impacted areas.

3. Laboratory studies on the sensitivities of key species from each habitat type. Such studies would be useful in selecting species to be monitored. The fate of sensitive and resistant species at an impact site could be used to estimate the magnitude of the impact.

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Table 1. Locations and distribution of sampling effort for epibenthos, infauna and intertidal fauna in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago during 1974-1981.

Location				Date		No. of Intertidal Samples	Epibenthos Samples		Infauna Samples		Physical/Chemical Environment		
Code[a]	Name	Lat.	Long.	Coll.	Anal.		Gear[b]	No.	Gear[c]	No.	Sub-strate[d]	Temp./ Salin.	Chl.a/ Nuts.[e]
A	Philpots Island	74°50'N	80°00'W	08/78	78-79	13	DO	-	VV AL2	4 15	GS	x	x
B	Cape Fanshawe	73°34'N	77°28'W	08/79	79-80	-	DO	-	P1	13	GS	-	-
B	Possession Bay	73°31'N	77°16'W	08/79	79-80	-	-	-	P1	21	GS	-	-
C	Phoenix Head Glacier	74°35'N	81°15'W	08/78	78-79	25	OT2 DO	6 -	VV AL2	9 13	GS	x	x
D	Croker Bay	74°40'N	83°15'W	09/78	78-79	9	-	-	-	-	VO	x	-
E	Navy Board Inlet	73°40'N	81°30'W	09/78	78-79	13	OT2	1	VV	6[f]	VO	x	-
F1	Eclipse Sound	72°30'N	78°30'W	09/78	78-79	23	OT2 DO	3 -	VV AL2	3 11	GS	x	x
F2	Cape Hatt	72°27'N	79°51'W	08/81	81-82	30	DO	-	AL3	190	GS	-	-
G	Scott Inlet	71°13'N	71°15'W	09/78	78-79	-	DO	-	VV AL2	8 5	GS	x	x
H	Allen Bay	74°44'N	95°05'W	08/77	84-85	20	OT1	2	-	-	VO	x	-
I	Cunningham Inlet	74°06'N	93°50'W	08/74	84-85	-	-	-	P1 P2	3 14	VO VO	x	x
J	Resolute Bay	74°40'N	94°54'W	06/76	76-77	-	OT1 CT	4 9	-	-	-	x	x
J	Assistance Bay	74°37'N	94°30'W	08/75	84-85	-	-	-	P1	19[f]	VO	x	x
K	Wellington Channel	74°44'N	91°54'W 93°25'W	06/76	76-77	-	OT1	6	-	-	-	x	x
L	Barrow Strait	74°10'N	97°00'W	08/74	84-85	-	-	-	SH	11	VO	x	x
M	Aston Bay	73°40'N	94°43'W	08/77	84-85	17	OT1	9	P1	11	VO	x	x
N	Brosman Peninsula	73°31'N	97°31'W	08/77	84-85	12	OT1	6	P1	11	VO	x	x
O	Little Cornwallis Island	75°33'N	96°18'W	08/77	84-85	21	OT1	6	P1	11	VO	x	x
P	Byam Martin Island	75°24'N	104°00'W	08/77	84-85	15	OT1	3	P1	12	VO	x	x
Q	Richardson Point	75°36'N	105°25'W	08/77	84-85	10	-	-	P1	13	VO	-	-
R	Graham Moore Bay	75°31'N	102°30'W	08/77	84-85	15	OT1	3	P1	19	VO	x	N
S	Bridport Inlet	75°03'N	108°45'W	08/77	77-78	21	OT1	6	P1	18	VO	x	x
T	Creswell Bay	72°45'N	94°00'W	08/75	84-85	-	-	-	P1 P2	30 11	VO VO	x	x
U	Brentford Bay	71°48'N	94°32'W	08/77	77-78	15	OT1	7	P1	11	VO	x	x
W	Bellot Strait	72°01'N	94°28'W	07/77	84-85	7	OT1	1	P1	4	VO	x	N

[a] See Fig. 1.
[b] DO = diver observations; OT1 = 2.5 m Otter trawl; OT2 = 3 m Otter trawl; CT = Cobb trawl.
[c] VV = Van Veen grab; P1 = 0.05 m^2 Ponar grab; P2 = 0.02 m^2 Ponar grab; AL2 = 0.15 m^2 airlift; AL3 = 0.0625 m^2 airlift; SH = Shipek grab 0.04 m^2.
[d] VO = visual observations; GS = grain size analysis.
[e] x = Chlorophyll a and nutrients; N = nutrients only.
[f] Samples not quantitative.
- no samples collected.
x Samples collected.

Table 2. Summary of physical characteristics of infaunal and intertidal study sites in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago.

Location[a]	Coast Type: Semi-Enclosed Bay	Open Bay	Open Coast	River Delta	Strait	Wave Exposure Index[b]	% of Samples Containing Substrate Type[c]: Intertidal Rock	Cobble	Pebble	Sand	Silt	Clay	0-5 m Rock	Cobble	Pebble	Sand	Sandy Silt	Silt	Silty Clay	Clay	6-20 m Rock	Cobble	Pebble	Sand	Sandy Silt	Silt	Silty Clay	Clay	21-55 m Rock	Cobble	Pebble	Sand	Sandy Silt	Silt	Silty Clay	Clay
Philpots Island	x	x	x	x	x	74	85	92	69	62	0	0	0	0	0	100	0	0	0	0	30	0	30	100	0	0	0	0	0	0	0	100	0	0	0	0
Cape Faraday[d]			x			78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	100	-	50	-	50	-	-	100	100	-	100	-	67
Possession Bay[d]			x			60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	100	-	25	-	13	-	-	13	100	-	38	-	0
Phoenix Head Glacier			x			74	92	96	80	32	4	0	0	0	0	75	0	0	0	0	25	50	75	50	25	25	25	8	0	100	100	0	83	0	17	50
Eclipse Sound			x			44	83	83	78	52	4	0	100	100	100	100	0	0	0	0	33	33	33	33	33	67	0	0	33	0	0	100	0	100	0	0
Cape Hatt[d] Bay 7	x					2	-	-	-	-	-	-	61	100	70	100	-	91	-	0	75	92	29	100	-	100	-	13	-	-	-	-	-	-	-	-
Bay 9	x					6	100	100	100	30	0	0	25	75	46	100	-	67	-	0	0	20	0	100	-	100	-	0	-	-	-	-	-	-	-	-
Bay 10	x					6	90	60	30	40	10	0	0	75	50	100	-	96	-	0	7	64	0	100	-	100	-	0	-	-	-	-	-	-	-	-
Bay 11	x					6	90	100	100	80	0	0	0	83	88	100	-	71	-	0	0	43	38	100	-	100	-	52	-	-	-	-	-	-	-	-
Scott Inlet			x			77	-	-	-	-	-	-	0	0	0	100	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	83	17	17	0	17
Cunningham Inlet Inner				x		4	-	-	-	-	-	-	0	0	0	0	50	50	50	0	0	0	0	0	0	25	75	0	0	0	0	0	0	40	60	0
Outer	x					43	-	-	-	-	-	-	0	50	100	0	0	50	50	0	0	25	0	0	25	75	0	0	0	0	0	0	0	0	100	0
Aston Bay	x					3	82	76	24	0	18	0	0	0	50	0	50	50	0	0	0	0	17	17	17	33	67	0	0	0	0	0	0	100	0	0
Brodeur Peninsula		x				33	0	42	25	92	0	0	0	0	67	100	0	0	0	0	0	50	33	100	0	0	0	0	0	33	33	100	0	0	0	0
Little Cornwallis Island		x				8	86	100	67	5	14	0	40	20	40	20	20	60	0	0	67	33	50	0	0	100	17	0	-	-	-	-	-	-	-	-
Byam Martin Island			x			81	0	20	33	80	27	0	0	0	0	100	0	0	0	0	0	0	29	0	86	0	14	0	0	0	100	0	100	0	0	50
Richardson Point			x			74	0	0	0	100	0	0	0	0	0	100	0	0	0	0	-	-	-	-	-	-	-	-	0	0	0	0	100	0	0	0
Graham Moore Bay			x			63	0	87	0	100	0	0	0	20	20	80	20	0	0	0	0	11	22	44	22	11	22	0	0	50	50	0	0	33	50	33
Bridport Inlet 1	x					21	-	-	-	-	-	-	0	0	0	0	0	0	100	0	0	0	0	0	0	0	100	75	0	0	0	0	0	0	0	100
2				x		23	56	33	0	33	67	0	0	0	0	0	100	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	100	0
3	x					21	0	11	33	67	22	11	0	0	0	0	0	0	100	0	0	0	0	0	0	0	100	33	0	0	0	0	0	0	100	0
Creswell Bay Inner	x					2	-	-	-	-	-	-	0	0	0	0	100	0	0	0	0	0	0	29	57	14	14	0	0	0	0	67	33	0	0	0
Outer				x		63	-	-	-	-	-	-	9	9	36	45	36	0	27	0	0	18	0	18	36	9	45	0	0	0	0	0	43	0	57	0
Brentford Bay	x					7	80	73	60	47	0	0	0	0	20	40	20	0	0	40	29	0	14	57	43	57	0	0	20	60	40	20	0	40	20	0
Ballot Strait					x	9	57	57	43	57	14	0	0	100	50	50	0	0	0	0	0	50	75	100	0	50	0	0	100	0	0	0	0	0	0	0

[a] See Figure 1.
[b] After Beaufort (1970).
[c] Presence or absence of each substrate type recorded for each sample, except as noted.
[d] Data derived from grain size analysis for each sample; see 'Methods' section.

Table 3. Summary of data on the chemical environment at study sites in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago. Samples were taken at 0 or 1 m, 5 or 7.5 m, 10 or 15 m, 20 or 25 m, 30, 40 and 50 m. Values are means for all samples with the indicated depth.

Location		Freshwater Influence: Glacier	Major River	Seasonal River	Stream	Dry	Water Sampling Day/Mo.	Temperature °C: 0-5 m	6-20 m	21-55 m	Salinity °/oo: 0-5 m	6-20 m	21-55 m	Chlorophyll a mg/m³: 0-5 m	6-20 m	21-55 m	Nitrate-Nitrite µmol/L: 0-5 m	6-20 m	21-55 m	Phosphate µmol/L: 0-5 m	6-20 m	21-55 m	Silicate µmol/L: 0-5 m	6-20 m	21-55 m
Philpots Island						x	23/08	0.3	0.4	-0.3	31.4	31.7	32.5	1.66	2.44	1.09	0.06	0.05	4.09	0.47	0.39	0.88	5.05	3.55	11.10
Cape Fanshawe				x	x		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Possession Bay				x	x		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phoenix Head Glacier		x					28/08	0.6	0.5	-0.2	31.1	31.9	32.5	1.80	2.07	1.33	0.05	0.00	1.15	0.17	0.25	0.36	1.93	2.09	3.94
Eclipse Sound					x		13/09	1.1	0.0	-1.0	25.4	29.9	32.2	0.24	0.62	0.92	0.00	0.02	5.27	0.33	0.39	1.07	4.21	2.87	12.53
Cape Hatt	Bay 7			x			10/08	4.3	1.9	-	23.3	30.9	-	0.70	2.11	-	0.00	0.00	-	0.16	0.38	-	-	-	-
	Bay 9			x			10/08	4.1	1.8	-	24.0	30.7	-	0.67	2.04	-	0.17	0.17	-	0.16	0.38	-	-	-	-
	Bay 10			x			12/08	2.2	1.8	-	30.8	31.3	-	1.96	3.34	-	0.07	0.10	-	0.29	0.44	-	-	-	-
	Bay 11			x			12/08	1.9	1.6	-	31.3	31.5	-	2.59	2.88	-	0.12	0.13	-	0.38	0.38	-	-	-	-
Scott Inlet			x				18/09	0.1	-0.1	-0.0	29.9	30.4	30.9	0.61	0.63	0.76	0.07	0.02	0.04	0.29	0.40	0.45	1.53	1.90	2.15
Cunningham Inlet	Inner		x				21-25/08	2.7	0.5	-1.0	17.5	29.4	31.7	0.88	0.86	-	0.98	4.37	-	0.51	0.83	-	2.97	4.49	-
	Outer			x			16-26/08	1.4	0.3	-1.2	22.8	29.0	31.4	1.45	-	-	0.41	-	-	0.62	-	-	1.84	-	-
Aston Bay				x			06/08	2.7	0.5	-	31.4	32.1	-	0.07	0.00	-	0.4	0.2	-	0.77	0.84	-	3.7	3.3	-
Brodeur Peninsula				x			22/08	1.1	0.6	-0.1	31.3	31.8	32.5	0.2	0.25	0.11	0	0.1	0.1	0.76	0.75	0.86	0.5	0.9	1.3
Little Cornwallis Island				x			14/08	0.3	-0.5	-	31.2	31.9	-	0.07	0.08	-	0.1	0	-	0.59	0.68	-	1.3	0.5	-
Byam Martin Island				x			23/08	0.0	-0.4	-1.2	28.9	31.2	32.4	0.27	1.20	1.99	0.7	0.75	3.1	0.75	0.90	1.15	4.5	5.55	12.55
Richardson Point				x			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Graham Moore Bay				x			08/08	1.6	-0.4	-1.4	26.2	27.5	32.5	-	-	-	0.3	0.25	1.95	0.7	0.83	1.08	4.4	3.7	8.7
Bridport Inlet	1			x			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2		x				08/08	2.5	-0.2	-1.25	-	-	-	-	-	-	0.15	0.09	0.49	0.62	0.81	0.97	4.0	5.4	5.6
	3				x		09/08	0.8	-0.2	-	29.5	30.4	-	-	-	-	0.15	0.16	-	0.88	0.85	-	4.7	4.4	-
Creswell Bay	Inner		x				08/08	4.0	2.2	-	5.7	28.9	-	-	-	-	-	-	-	-	-	-	-	-	-
	Outer		x				03/08	2.7	1.4	-	21.7	30.0	-	0.56	0.62	-	0.49	0.08	-	0.50	0.81	-	1.86	1.17	-
Brentford Bay				x			02/09	1.7	-0.5	-0.8	26.9	30.8	31.2	0.36	0.14	0.11	2.6	0.6	2.2	0.53	0.74	0.96	1.23	1.48	6.65
Bellot Strait				x			27/07	-0.8	-0.9	-	31.8	32.0	-	-	-	-	1.8	3.1	-	0.81	1.01	-	7.8	7.4	-

Table 4. Numbers and biomass of animals in various strata of the substrate at Cape Hatt, Baffin Island.

Sample No.	Depth of Penetration (cm)	Infauna in 0.0625 m^2 sample			
		g	%	no.	%
1	0-3	44.3	44	109	81
	3-5	55.6	56	25	19
	0-5	99.9	100	134	100
2	0-5	180.8	65	216	94
	5-10	96.7	35	14	6
	0-10	277.5	100	230	100
3	0-10	192.6	55	271	91
	10-15	158.6	45	26	9
	0-15	351.2	100	297	100
4	0-10	131.2	72	98	86
	10-20	51.4	28	16	14
	0-20	182.6	100	114	100

Table 5. Sediment penetration depths of the grab samplers used in various locations in the eastern and central Canadian Arctic.

Location	Water Depth ⟶ / Sampler	Penetration depth (cm) by water depth ranges					
		0-5 m		6-20 m		21-55 m	
		Mean	n	Mean	n	Mean	n
Philpots Island	Van Veen	-	-	3.3	1	2.3	3
Cape Fanshawe	Ponar	4.1	2	1.6	3	1.6	6
Possession Bay	Ponar	2.9	3	1.5	9	0.7	8
Phoenix Head Glacier	Van Veen	-	-	3.0	3	3.7	6
Eclipse Sound	Van Veen	-	-	-	-	4.6	3
Scott Inlet	Van Veen	-	-	1.3	2	2.5	6
Aston Bay	Ponar	4.5	2	3.4	7	3.4	2
Brooman Peninsula	Ponar	3.2	3	2.0	4	2.0	2
Little Cornwallis Island	Ponar	2.1	5	1.6	5	-	-
Byam Martin Island	Ponar	3.8	3	2.5	7	2.9	2
Richardson Point	Ponar	2.0	2	3.7	4	3.4	6
Graham Moore Bay	Ponar	2.5	5	4.6	8	6.5	6
Bridport Inlet 1	Ponar	7.7	1	8.1	4	11.5	1
3	Ponar	0.6	1	4.2	3	-	-
Brentford Bay	Ponar	0.6	3	1.9	5	5.6	2
Bellot Strait	Ponar	2.1	1	1.2	3	-	-

Table 6. Mean density and biomass of infauna at study sites in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago.

Location		Density (no.m^{-2})			Biomass (g.m^{-2})		
		0-5 m	6-20 m	21-55 m	0-5 m	6-20 m	21-55 m
Philpots Island		1960	2716	2313	28	183	480
Cape Fanshawe		0	824	3413	0	192	317
Possession Bay		0	2928	7659	0	88	357
Phoenix Head Glacier		207	2773	3238	12	270	876
Eclipse Sound		1102	3373	2706	68	327	251
Cape Hatt	Bay 7	1953	5110	-	170	1033	-
	Bay 9	4409	5579	-	678	1507	-
	Bay 10	2688	4360	-	341	1286	-
	Bay 11	1374	4899	-	60	1369	-
Scott Inlet		5856	3272	1781	21	65	102
Cunningham Inlet	Inner	1312	1487	1075	125	467	192
	Outer	1142	2432	1011	47	689	33
Aston Bay		694	1289	1824	64	255	213
Brooman Peninsula		1140	896	220	29	38	7
Little Cornwallis Island		935	804	-	8	164	-
Byam Martin Island		2071	1265	1387	8	99	88
Richardson Point		247	2998	1590	6	178	189
Graham Moore Bay		2535	1142	1070	101	585	121
Bridport Inlet	1	57	1701	361	2	201	88
	2	0	1819	741	2	13	28
	3	3876	4155	1368	60	458	69
Creswell Bay	Inner	1742	2640	2405	45	260	374
	Outer	117	1057	1748	3	233	256
Brentford Bay		811	1140	1697	36	108	212
Bellot Strait		3971	868	-	57	27	-
Mean of all sites		2031	3266	2649	198	679	292

Table 7. Infaunal benthic biomass in various arctic locations.

Location	Method	Infaunal biomass (g wet weight.m^{-2}) within depth ranges						Reference
		0–5 m		6–20 m		21–55 m		
		Mean(s)[a]	n	Mean(s)[a]	n	Mean(s)[a]	n	
Alaskan Beaufort Sea	0.1 m^2 grab	5–34	5	31–75	10–15	33,51	27,20	Carey et al. 1974; Carey 1978
Melville Island[c]	0.25 m^2 shallow airlift	135	12	229	47	–	–	Buchanan et al. 1977[d]
Boothia Peninsula[c]	0.25 m^2 shallow airlift	439	2	352	7	–	–	Thomson et al. 1978[d]
Barrow Strait	0.02/0.05 m^2 grab	8–125	2–5	38–689	4–7	7–213	2	Present study
Viscount Melville Sound	0.05 m^2 grab	2–101	1–5	13–585	3–8	28–189	1–6	Present study
Prince Regent Inlet	0.02/0.05 m^2 grab	3–57	1–11	27–260	3–11	212–374	3–7	Present study
Lancaster Sound/Baffin Bay	0.05/0.13 m^2 grab; 0.15 m^2 shallow airlift	0–28	2–6	65–270	3–12	102–876	3–9	Present study
Northern Baffin Island	0.07/0.1 m^2 grab	31,35	11,6	201,210	8,4	327	43	Ellis 1960
Cape Hatt	0.06 m^2 deep airlift	59–1074	24	933–2267	24	–	–	Cross et al. 1984[d]
Northwest Greenland	0.1 m^2 grab	–	–	52–1482	6–12	–	–	Vibe 1939
West Greenland	0.1 m^2 grab	–	–	48–320	10–39	–	–	Ellis 1960

[a] Means and sample numbers are given for sub-locations within locations or discrete depth ranges within depth ranges.
[b] Ranges shown are for four bays and six sampling periods (1980–1983).
[c] Airlift samples from study sites that were not included for analysis during the present study.
[d] Data from these sites are included in the present study.

Table 8. Group composition (% of total infaunal numbers) of infaunal benthos at study sites in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago.

Location		Polychaeta			Bivalvia			Echinodermata			Amphipoda			Ostracoda			Cumacea		
		0-5 m	6-20 m	21-55 m	0-5 m	6-20 m	21-55 m	0-5 m	6-20 m	21-55 m	0-5 m	6-20 m	21-55 m	0-5 m	6-20 m	21-55 m	0-5 m	6-20 m	21-55 m
Philpots Island		16	10	9	1	3	35	<1	1	7	77	60	3	<1	<1	2	3	20	42
Cape Parshaw		-	40	12	-	7	17	-	10	11	-	2	13	-	22	25	-	8	12
Possession Bay		-	20	17	-	7	6	-	2	3	-	2	1	-	<1	10	-	66	63
Phoenix Head Glacier		11	15	12	<1	13	40	<1	5	16	70	33	1	<1	25	22	14	7	7
Eclipse Sound		39	12	14	37	42	15	1	1	2	9	6	1	<1	33	61	<1	3	5
Cape Hatt	Bay 7	44	15	-	15	28	-	6	1	-	6	6	-	1	41	-	1	1	-
	Bay 9	43	18	-	28	38	-	6	1	-	5	5	-	1	31	-	3	2	-
	Bay 10	55	18	-	24	33	-	3	1	-	6	5	-	1	36	-	1	1	-
	Bay 11	57	20	-	11	33	-	7	<1	-	14	7	-	<1	27	-	2	4	-
Scott Inlet		37	15	41	24	30	19	<1	<1	4	12	6	3	<1	<1	25	24	45	5
Cunningham Inlet	Inner	46	27	62	34	69	26	<1	<1	<1	3	2	2	<1	<1	<1	2	<1	<1
	Outer	56	36	79	20	9	9	<1	1	<1	8	8	<1	<1	28	<1	<1	7	4
Aston Bay		55	19	19	21	62	69	4	2	1	7	11	7	8	<1	<1	1	2	2
Brodeur Peninsula		17	24	48	2	36	33	<1	5	<1	77	26	<1	1	2	<1	1	1	13
Little Cornwallis Island		84	24	-	3	33	-	1	2	-	7	11	-	1	13	-	2	10	-
Byam Martin Island		98	63	40	<1	25	42	<1	2	5	2	2	2	<1	3	4	<1	2	<1
Richardson Point		89	18	27	4	53	27	<1	<1	2	<1	24	28	<1	<1	<1	<1	2	12
Graham Moore Bay		83	36	22	8	45	21	<1	1	6	8	5	7	1	6	35	<1	2	2
Bridport Inlet	1	100	47	47	0	22	47	0	3	<1	0	5	<1	0	17	<1	0	2	<1
	2	-	96	83	-	<1	9	-	1	4	-	3	<1	-	<1	<1	-	<1	3
	3	10	35	3	6	27	92	<1	4	1	76	5	<1	4	25	<1	<1	2	3
Creswell Bay	Inner	56	82	43	22	6	44	4	2	5	11	5	2	<1	<1	<1	1	2	2
	Outer	12	36	80	4	14	13	2	2	2	80	7	6	<1	26	<1	2	10	1
Beaufort Bay		74	44	41	7	19	8	2	1	4	10	22	3	1	1	30	5	5	2
Bellot Strait		98	56	-	<1	9	-	<1	11	-	1	8	-	<1	3	-	<1	1	-
Mean of all sites		49	22	25	20	30	19	4	2	6	19	13	8	1	26	15	3	6	27

Table 9. Results of a factor analysis of the 39 most abundant benthic animals taken by grab and airlift in northern Baffin Bay, Lancaster Sound, and the central arctic islands between 1974 and 1981. The values shown are the correlations between the log-transformed abundances of various species (the original variables) and each of the nine factors determined in the analysis. Species whose abundances were weakly correlated with a factor ($-0.3<r<0.3$) are not shown. Each factor is assigned a name (beside number) indicating some or all of the main type(s) of animals represented.

1. Macoma	Variance explained 16.5%
Macoma calcarea	0.860
Pectinaria granulata	0.815
Macoma spp. juveniles	0.761
Trichotropis borealis	0.696
Ostracoda spp.	0.638
Mya truncata	0.616
Brachydiastylis resima	0.603
Nuculana minuta	0.596
Pholoe minuta	0.555
Ophiura robusta	0.542
Thyasiridae	0.534
Guernea sp.	0.531
Astarte montagui	0.487
Astarte borealis	0.387
Cingula castanea	0.386
Astarte spp. juveniles	0.354
Serripes groenlandicus	0.349
Musculus spp. juveniles	0.371

2. Astarte	Variance explained 8.0%
Astarte spp. juveniles	0.683
Astarte borealis	0.671
Astarte montagui	0.641
Praxillella praetermissa	0.586
Sabellidae spp.	0.584
Scoloplos armiger	0.458
Ostracoda spp.	0.307

3. Polychaetes	Variance explained 7.2%
Nereimyra punctata	0.682
Capitellidae spp.	0.654
Eteone longa	0.651
Ampharetidae spp.	0.535
Spionidae spp.	0.398
Pholoe minuta	0.393
Sabellidae spp.	0.384

4. Myriotrochus	Variance explained 7.2%
Myriotrochus rinkii	0.728
Cingula castanea	0.617
Cephalaspidea spp.	0.498
Musculus spp. juveniles	0.453
Mya truncata	0.443
Pholoe minuta	0.421
Eteone longa	0.336
Nereimyra punctata	0.335
Guernea spp.	0.330
Serripes groenlandicus	0.318

5. Crustacea	Variance explained 5.9%
Paroediceros lynceus	0.710
Lampropos fuscata	0.661
Monoculodes spp.	0.619
Spionidae spp.	0.502
Capitellidae spp.	0.374
Portlandia arctica	-0.315

6. Maldane/Nuculana	Variance explained 5.3%
Maldane sarsi	0.702
Nuculana minuta	0.444
Serripes groenlandicus	0.429
Cephalaspidea spp.	0.380
Ostracoda spp.	0.373
Guernea spp.	0.357
Pontoporeia femorata	0.342
Praxillella praetermissa	0.315

7. Owenia/Diastylis	Variance explained 5.1%
Owenia fusiformis	0.785
Diastylis spp.	0.773
Ophiura robusta	0.428
Brachydiastylis resima	0.372

8. Portlandia	Variance explained 4.8%
Cirratulidae spp.	0.656
Portlandica arctica	0.647
Aricidea spp.	0.566
Thyasiridae spp.	0.425
Scoloplos armiger	0.404
Cephelaspidea spp.	0.301

9. Protomedia	Variance explained 3.2%
Protomedia fasciata	0.766
Spionidae spp.	-0.431

Table 10. Biomass (all taxa) and sediment characteristics of sampling areas and depths that had a relatively high abundance of the indicated animal assemblages and a low abundance of other assemblages. Animal assemblages were determined in factor analysis.

	Depth (m)	N	Biomass mean ± s.d.	Grain size (Φ) Mean ± sorting	% of Samples with Sand	Silt	Clay
1. Macoma							
Phoenix Head Glacier	21-55	6	876 ± 701	3.7 ± 2.2	83	83	50
Cape Hatt Bay 7	7	24	1033 ± 692	4.1 ± 2.7	100	100	13
Bay 9	7	24	1507 ± 901	3.5 ± 2.1	100	100	0
Bay 10	7	24	1286 ± 660	3.8 ± 2.3	100	100	0
Bay 11	7	24	1369 ± 799	3.8 ± 3.2	100	100	52
2. Astarte							
Byam Martin Island	6-20	7	99 ± 136	-	86	86	14
	21-55	2	88 ± 78	-	100	100	50
Little Cornwallis Island	6-20	6	164 ± 134	-	0	100	17
Richardson Point	21-55	6	189 ± 203	-	100	100	0
Cape Hatt Bay 10	3	24	341 ± 273	3.3 ± 2.3	100	88	0
Lancaster Sound and Eclipse Sound[a]	5-50	5[a]	435 ± 378	2.8 ± 1.3	-	-	-
3. Polychaetes							
Brentford Bay	0-5	3	36 ± 19	-	40	20	40
Byam Martin Island	0-5	3	8 ± 7	-	100	0	0
Cape Hatt Bay 7	0-5	24	170 ± 176	2.6 ± 2.4	100	90	0
Bridport Inlet 2	6-20	4	13 ± 7	-	0	100	0
5. Crustacea							
Scott Inlet	0-5	2	21 ± 2	2.9 ± 0.6	100	0	0
Philpots Island	0-5	3	28 ± 7	0.5 ± 0.8	100	0	0
	6-20	6[a]	-	2.6 ± 0.9	100	0	0
Brosman Peninsula	0-5	3	29 ± 29	-	100	0	0
	6-20	6	-	2.9 ± 1.0	50	25	25
6. Maldane Nuculana							
Eclipse Sound	21-55	3	251 ± 331	4.8 ± 2.4	100	100	0
Cunningham Inlet (outer)	6-20	4	689 ±1078	-	25	75	-
Brentford Bay	21-55	3	212 ± 188	-	20	40	20
Bridport Inlet 1	6-20	4	201 ± 130	-	0	100	75
7. Owenia Diastylis							
Possession Bay	6-20	9	88 ± 122	3.2 ± 1.1	100	25	13
	21-55	9	357 ± 293	3.3 ± 1.1	100	38	0
Scott Inlet	21-55	6	102 ± 87	4.0 ± 2.0	83	17	17
Cape Vanshawe	21-55	7	317 ± 283	3.0 ± 2.9	100	100	67
8. Portlandia							
Aston Bay	6-20	7	255 ± 158	-	17	67	67
	21-55	2	213 ± 249	-	0	100	0
Cunningham Inlet (inner)	0-5	2	125 ± 22	-	50	50	50
	6-20	5	467 ± 114	-	0	75	75
	21-55	2	192 ± 44	-	0	60	60
Bridport Inlet 3	6-20	3	458 ± 210	-	0	100	100
9. Protomedia							
Eclipse Sound	0-5	2[a]	67.5 ± 14.3	1.6 ± 1.3	100	100	0
Philpots Island	0-5	3[a]	32.9 ± 6.0	2.2 ± 0.9	100	0	0
	10	3[a]	24.9 ± 5.9	2.8 ± 0.8	100	0	0
Brosman Peninsula	2	2	12.8 ± 6.2	-	100	0	0

[a] Only those samples with a dominance of the indicated assemblage are included.

Table 11. Biomass ($g.m^{-2}$) of infaunal benthos collected in the Canadian high Arctic. Data are expressed as mean ± standard deviation (sample size in parentheses).

Depth (m)	NW Baffin Bay	Lancaster Sound	Eclipse Sound	Barrow Strait
0-5	14 ± 15 (12)	12 ± 7 (4)	307 ± 371 (97)	86 ± 54 (4)
6-20	145 ± 218 (22)	270 ± 280 (12)	1215 ± 796 (104)	566 ± 675 (9)
21-55	362 ± 293 (19)	876 ± 701 (6)	251 ± 331 (3)	113 ± 96 (4)
56-105	451 ± 175 (8)	1091 ± 276 (6)	52 ± 23 (2)	65 (1)
106-250	183 ± 138 (12)	180 ± 40 (4)	134 ± 234 (7)	34 ± 30 (8)
251-500	49 ± 23 (8)	153 (1)	24 ± 12 (3)	6.4 (1)

Table 12. Mode of feeding and motility classification of infaunal benthos from sampling areas categorized by exposure index and by region. The mean density of each mode of feeding or motility group is expressed as a percentage of the total density of infauna. Crustaceans are not included.

	Feeding Mode (% of total density)												Motility (% of total density)									Mean total density ($no.m^{-2}$) (sample size)		
	Deposit feeders			Surface deposit feeders			Filter feeders			Carnivores			Motile			Discretionary motile			Sessile					
Depth Range (m) ⟶	0-5	6-20	21-55	0-5	6-20	21-55	0-5	6-20	21-55	0-5	6-20	21-55	0-5	6-20	21-55	0-5	6-20	21-55	0-5	6-20	21-55	0-5	6-20	21-55
By Exposure Index																								
Channels and Bays <25	16	20	13	49	45	58	18	19	16	17	16	14	41	57	59	36	24	29	23	18	13	922 (18)	1301 (44)	1192 (14)
Channels and Bays >25	1	13	17	60	37	35	32	37	34	7	13	14	13	35	39	55	27	44	32	38	17	829 (28)	1287 (50)	1008 (28)
Eastern Arctic >25	11	9	7	56	41	42	22	34	41	10	16	10	51	43	41	26	28	27	22	29	32	580 (18)	967 (39)	1924 (33)
By Region																								
N.W. Baffin Bay	25	6	5	45	24	33	7	54	52	24	16	10	50	30	41	42	42	36	8	29	24	205 (12)	775 (22)	2038 (19)
Lancaster Sound	4	11	5	43	54	71	17	17	18	36	18	7	40	48	43	43	15	9	17	37	49	42 (4)	1158 (12)	2659 (6)
Eclipse Sound	15	9	17	18	25	47	24	43	24	43	23	12	59	39	44	13	26	24	28	36	32	2845 (97)	3073 (104)	965 (3)
Barrow Strait	0	12	10	51	52	54	19	17	8	30	20	27	55	62	48	14	15	44	32	23	8	1086 (4)	1497 (9)	1032 (4)
Crozier Strait	16	12	0	46	32	42	31	47	38	7	9	21	24	24	42	35	36	42	42	39	17	613 (8)	635 (12)	228 (2)
Austin Channel[a]	1	14	17	65	47	45	33	25	25	2	14	14	7	44	46	62	32	36	31	24	17	1460 (13)	1603 (31)	870 (18)
Peel Sound	9	7	4	25	60	73	9	23	15	57	10	8	75	64	68	12	20	13	13	16	19	646 (2)	1154 (7)	1720 (2)
Boothia Peninsula	23	34	18	56	27	34	10	20	37	11	20	12	35	56	42	51	22	46	14	21	12	467 (17)	944 (26)	1410 (13)

a Includes Bridport Inlet.

Table 13. Biomass of macroalgae from various locations in the study area. From Thomson and Cross (1980) and Cross et al. (1984).

Location	Total Biomass of Macroalgae ($kg.m^{-2}$)[a]	
	5 m Depth	10 m Depth
Philpots Island	3.8 to 5.3 (2)	2.2 (1)
Phoenix Head Glacier	-	1.7 to 4.4 (3)
Navy Board Inlet	-	5.1 to 13.2 (2)
Cape Fanshawe	0.7 ± 0.2 (5)	0.4 ± 0.2 (6)
Eclipse Sound	1.5 ± 3.6 (2)	1 to 1.7 (2)
Cape Hatt[b]	0.4 ± 0.2 (8) to 1.1 ± 0.8 (8)	0.2 ± 0.1 (8) to 0.4 ± 0.2 (8)

[a] Range or mean ± s.d., sample size in parentheses.
[b] 3 m and 7 m, range of means in the three experimental bays, eight samples per bay, 1980 data only.

Table 14. Chlorophyll a and nitrogen concentrations at depth and integrated over the 0-50 depth range from 15 sites in the central and eastern Canadian Arctic.

		Chlorophyll *a*							Nitrate		
		mg.m^{-2}[a]	mg.m^{-3}						mg At-N.m^{-2}	mg At-N.m^{-3}	
	Year	0-50 m	0 m	5 m	10 m	15-20 m	25-30 m	40-50 m	0-50 m	0 m	10 m
Open Coasts and Channels											
Lancaster Sound											
23 Jul-18 Aug	1978	79.6 (37)	0.98	1.07	1.21	2.22	1.86	0.41	181	-	-
19 Aug-17 Sep	1978	69.5 (28)	0.64	0.67	0.97	1.57	2.49	0.49	83	-	-
18 Sep-10 Oct	1978	74.5 (38)	1.59	1.58	1.66	1.71	1.78	0.76	103	-	-
Peel Sound 30 Aug		17 (1)	0.23	-	-	0.30	-	0.47	172	1.66	-
Barrow Strait											
Assistance Bay 19-25 Aug	1975	78.2 (1)	0.77	-	1.08	2.25	2.06	1.36	45	0.05	0.14
Allen Bay 28 Aug	1977	>60 (3)	1.0	-	2.16	2.38	-	-	71	0.3	0
Austin Channel											
Byam Martin Is. 23 Aug	1977	80 (3)	0.27	-	0.98	1.41	2.03	1.95	193	0.7	0.3
Wellington Channel 2-22 Jun	1976	100 (23)[b]							285		
Barrow Strait 8 May[c]	1975	9.0 (1)	1.17	-	0.10	-	0.05	-	281	4.2	5.0
Enclosed Bays and Inlets											
Brentford Bay 2 Sep[d]	1977	10 (1)	0.80	-	0.27	0.14	0.10	0.11	218	<0.1	1.1
Bridport Inlet 5-28 Aug	1977	-	-	-	-	-	-	-	26	0.2	0.1
early Aug	1977	60 (5)	-	-	-	-	-	-	-	-	-
late Aug	1977	8 (2)	-	-	-	-	-	-	-	-	-
Cunningham Inlet (Inner)											
21-25 Aug	1975	26 (2)	0.88	-	-	0.86	-	-	98	1.0	4.4
Brosman Peninsula 22 Aug	1977	7 (1)	0.02	-	0.29	0.2	0.11	-	>2.5	0	0.1
Little Cornwallis Island 14 Aug	1977	- (2)	0.07	-	0.13	0.02	-	-	-	0.1	0
Aston Bay 6 Aug[d]	1977	- (1)	0.07	-	0.08	0.0	-	-	-	0	0
Creswell Bay (Outer) 2-3 Aug	1975	43 (1)	0.37	-	0.53	-	-	1.41	87	0.05	0.2
Bridport Inlet 9-14 Jun[c]	1977	<5 (2)	<0.1	-	<0.01	<0.1	<0.1	<0.1	159	1.0	2.6
Brentford Bay 23-27 May[c]	1977	1 (3)	0.02	-	0.02	0.02	0.02	0.02	422	8.1	8.8

[a] Number of stations in parentheses.
[b] 0-25 m depth.
[c] Underice station.
[d] Away from river.

Table 15. Productivity of three species of bivalve mollusc from Cape Hatt, N.W.T. Productivity was calculated for each bay using growth rates (Green et al., University of Western Ontario, unpublished), length frequency distributions and length vs dry weight relationships (Cross and Thomson 1981).

Species	Growth rate[a] ($mm.yr^{-1}$)	Standing crop[c] (g dry meat.m^{-2})	Productivity[d] (g dry meat.$m^{-2}.yr^{-1}$)	Productivity: biomass ratio
Bay 9				
Astarte borealis	0.86	11.393	1.341	0.12
Macoma calcarea	0.84	5.991	0.809	0.14
Mya truncata	2.31 to 0.71[b]	159.530	21.958	0.14
Bay 10				
Astarte borealis	0.86	12.259	1.356	0.11
Macoma calcarea	0.92	5.617	0.790	0.14
Mya truncata	2.31 to 0.71[b]	46.447	7.115	0.15
Bay 11				
Astarte borealis	0.82	14.136	1.950	0.14
Macoma calcarea	0.90	3.947	0.537	0.14
Mya truncata	2.31 to 0.71[b]	63.785	11.255	0.18

[a] From Green et al., University of Western Ontario, unpublished.
[b] Age dependent, decreasing with age.
[c] Dry meat weight not including shell.
[d] Ignores recruitment and gonad development.

Table 16. Mean numbers of animals collected in grab samples taken in cobble substrates at Navy Board Inlet and Assistance Bay. Because of the rocky nature of the substrate, samples were not considered to be quantitative.

Navy Board Inlet, Lancaster Sound		Assistance Bay, Barrow Strait		
Water Depth (m)	18–56	Water Depth (m)	1–10	11–56
Sample Size	6	Sample Size	8	11
Ophiura robusta	37[a]	*Spirorbis* spp.	3[b]	9[b]
Balanus crenatus	22	*Balanus crenatus*	5	10
Strongylocentrotus droebachiensis	12	*Hiatella arctica*	<1	1
Balanus balanoides	4	Gastropoda	1	1
Ophiopus arcticus	3	Chitons	<1	1
Gastropoda	2	*Strongylocentrotus droebachiensis*	<1	<1
Lophyrochiton albus	2	Ophiuroids	<1	1
Stephanasterias albula	1	*Hemithyrus psittacea*	0	<1
Hemithyrus psittacea	<1			

[a] Numbers per 0.13 m^2 Van Veen grab.
[b] Numbers per 0.05 m^2 Ponar grab.

Table 17. Results of quantitative airlift samples taken on exposed bedrock at Cape Fanshawe, Bylot Island. Attached animals were scraped from the surface.

5 m Depth		10 m Depth	
Taxon	% of total biomass	Taxon	% of total biomass
Hiatella arctica	39	Strongylocentrotus droebachiensis	44
Ischyrocerus anguipes	19	Psolus fabricii	20
Margarites sp.	14	Leptasterias polaris	18
Musculus discors	7	Actiniaria	16
Crenella faba	7	Brachiopoda	1
Total biomass	20 $g.m^{-2}$	Total biomass	253 $g.m^{-2}$
Area sampled	3.75 m^2	Area sampled	2 m^2

Table 18. Common large benthic animals taken by trawl in the central and eastern Canadian high Arctic. Data are expressed as mean (no./10 min tow) ± standard deviation. Approximate distance covered would have been between 400-1000 m.

Location	Depth (m)	*Strongylocentrotus droebachiensis*	Starfish	*Heliometra glacialis*	*Arcturus baffini*	Decapods	*Ophiocten sericeum*	Tunicates	Sample size
Phoenix Head Glacier	21-55	52 ± 48	2 ± 1	2 ± 4	108 ± 167	2 ± 2	0	4 ± 7	6
Navy Board Inlet	21-55	11	1	0	1	1	0	0	1
Eclipse Sound	21-55	14 ± 19	0 ± 1	9 ± 14	0	2 ± 1	0	0	3
Allen Bay	6-20	16 ± 14	0	0	177 ± 112	1 ± 1	0	2 ± 1	2
Resolute Bay[2]	0-5	0	0	0	0	0	0	0	3
	6-20	1 ± 2	0	0	0	2 ± 3	0	0	10
Wellington Channel	6-20	0	0	0	0	1 ± 2	0	0	3
	21-55	1 ± 1	1 ± 1	0	0	3 ± 6	0	0	3
Graham Moore Bay	0-5	0	0	0	0	0	2	0	1
	6-20	0	0	0	2 ± 2	0	13 ± 15	4 ± 5	2
Byam Martin Island	0-5	0	0	0	0	0	0	0	1
	6-20	1 ± 0	2 ± 3	0	0	1 ± 1	57 ± 30	1 ± 1	2
Little Cornwallis Island	0-5	2 ± 2	3 ± 3	0	0	15 ± 8	0	6 ± 6	4
	6-20	30 ± 37	0	0	0	19 ± 18	0	0	2
Broomsn Peninsula	0-5	0	1 ± 2	0	0	2 ± 3	1 ± 1	3 ± 4	4
	6-20	0	0	0	0	1 ± 1	9 ± 13	1 ± 1	2
Aston Bay	0-5	0	0	0	0	0	1 ± 1	0	3
	6-20	0	0	0	0	1 ± 1	12 ± 9	1 ± 2	6
Brentford Bay	0-5	2 ± 2	0	0	0	6 ± 8	0	0	4
	6-20	4 ± 2	1 ± 1	0	0	21 ± 5	5 ± 7	5 ± 1	2
	21-55	0	0	0	0	0	55	0	1
Bridport Inlet	6-20	2 ± 3	27 ± 38	13 ± 18	0	27 ± 38	0	0	2
	21-55	5 ± 5	76 ± 106	6 ± 12	0	36 ± 18	91 ± 181	1 ± 1	4

Table 19. Density and biomass of sea urchins and starfish from six locations in the Canadian high Arctic. Estimates are based on *in situ* counts and collections in large areas by divers.

Location	Depth (m)	Area sampled (m^2)	*Strongylocentrotus droebachiensis*		Starfish	
			$no.m^{-2}$	$g.m^{-2}$	$no.m^{-2}$	$g.m^{-2}$
Philpots Island	12	25	14	232	0	0
	20	10	0	0	0	0
Phoenix Head Glacier	10	2.5	0	0	0	0
	20	2.5	9	51	0	0
	20	2.5	9	69	0	0
Cape Fanshawe	5	5	0	0	0	0
	10	6	4	102	0.3	13.0
Eclipse Sound	5	0.25	0	0	0	0
	5	1	1	21	1	54
	10	1	10	426	0	0
	10	1	9	267	0	0
Cape Hatt Bay 9	7	150	4	-	1	-
Bay 10	7	150	2	-	2	-
Bay 11	7	150	1	-	1	-
Bridport Inlet	3-15	105	0.3	-	0.2	-

Table 20. Common decapod crustaceans in Otter trawls from locations where decapods were abundant.

	Mean number/10 min trawl					
	Little Cornwallis Island		Brentford Bay		Bridport Inlet	
	0-5 m	6-20 m	0-5 m	6-20 m	6-20 m	21-55 m
Sabinea septemcarinata	0	0	0	0	12	29
Sclerocrangon boreas	7	0	2	3	14	1
Sclerocrangon ferox	7	4	0	0	-	-
Lebbeus polaris	1	4	2	4	2	5
Lebbeus groenlandicus	0	10	2	15	-	-
Sample size	4	2	4	2	2	4

Table 21. Mean sizes of mysids collected at various depths in Brentford Bay, Boothia Peninsula.

Depth (m)	Mysis litoralis		Mysis oculata	
	Number	mean size ± s.d.	Number	mean size ± s.d.
1-2	56	9.3 ± 0.6	21	10.1 ± 0.6
5	6	17.3 ± 7.5	0	-
6	28	19.2 ± 4	1	-
20	3	21.7 ± 4.7	60	23.3 ± 2.5
30	0	-	75	23.4 ± 2.6

Table 22. Mean density (no.m^{-2} ± SD) of amphipods and percent contribution (% of total amphipod numbers) of epibenthic amphipods at study sites in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago.

Location		0-5 m		6-20 m		21-55 m	
Philpots Island		228 ± 117	(13)	484 ± 427	(23)	5 ± 9	(7)
Cape Fanshawe		621 ± 626	(100)	64 ± 111	(83)	96 ± 116	(18)
Possession Bay		173 ± 120	(100)	474 ± 908	(87)	280 ± 439	(78)
Phoenix Head Glacier		1280 ± 1094	(90)	369 ± 353	(29)	365 ± 391	(95)
Eclipse Sound		94 ± 104	(48)	78 ± 164	(28)	0	
Cape Hatt Bay 7		63 ± 68	(36)	21 ± 35	(6)	-	
Bay 9		48 ± 45	(19)	43 ± 65	(15)	-	
Bay 10		98 ± 227	(37)	49 ± 48	(18)	-	
Bay 11		26 ± 47	(12)	69 ± 64	(16)	-	
Scott Inlet		281 ± 66	(29)	118 ± 65	(37)	5 ± 8	(9)
Cunningham Inlet	Inner	258 ± 61	(86)	26 ± 38	(50)	0	
	Outer	247 ± 349	(74)	32 ± 42	(14)	-[a]	
Aston Bay		67 ± 40	(59)	46 ± 73	(25)	0	
Brooman Peninsula		374 ± 242	(30)	30 ± 29	(11)	-[a]	
Little Cornwallis Island		42 ± 28	(41)	25 ± 29	(21)	-	
Byam Martin Island		70 ± 121	(69)	5 ± 9	(17)	0	
Richardson Point		922 ± 1223	(100)	38 ± 45	(5)	25 ± 33	(5)
Graham Moore Bay		95 ± 139	(32)	171 ± 310	(75)	49 ± 41	(41)
Bridport Inlet	1	57	(100)	52 ± 39	(36)	361	(100)
	2	76	(100)	19 ± 16	(28)	48 ± 40	(100)
	3	38	(1)	0		-	
Creswell Bay	Inner	43 ± 61	(18)	94 ± 123	(40)	29 ± 50	(40)
	Outer	102 ± 97	(52)	34 ± 57	(30)	55 ± 59	(59)
Brentford Bay		209 ± 116	(72)	114 ± 116	(32)	25 ± 44	(33)
Bellot Strait		2945	(98)	63 ± 29	(47)	-	
Mean of all sites		158 ± 389	(30)	105 ± 260	(20)	94 ± 222	(31)

- No amphipods were collected.

Table 23. Mean density of epibenthic amphipods from sites grouped by exposure index.

Area	Exposure Index	Mean density ($no.m^{-2}$) ± s.d. (sample size)		
		0-5 m depth	6-20 m depth	21-55 m depth
Central Islands	<25[a]	260 ± 677 (18)	52 ± 76 (44)	44 ± 97 (14)
Central Islands	>25	195 ± 350 (28)	60 ± 149 (50)	30 ± 43 (28)
Eastern Arctic	>25	524 ± 678 (18)	367 ± 525 (39)	164 ± 310 (33)

[a] Not including sites at Cape Hatt.

Table 24. Mean density ($no.m^{-2}$) of major intertidal amphipods at study sites in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago. Data expressed as mean ± standard deviation.

Location		*Gammarus setosus*				*Onisimus litoralis*				*Onisimus glacialis*				*Onisimus nanseni*			
		Intertidal	0-5 m	6-20 m	21-55 m	Intertidal	0-5 m	6-20 m	21-55 m	Intertidal	0-5 m	6-20 m	21-55 m	Intertidal	0-5 m	6-20 m	21-55 m
Philpots Island		6 ± 10	0	0	0	25 ± 53	0	0	0	0	0	0	0	0	0	0	0
Cape Fanshaw		-	596 ± 627	51 ± 89	11 ± 22	-	13 ± 11	6 ± 11	0	-	0	0	0	-	0	0	0
Possession Bay		-	160 ± 128	0	0	-	13 ± 11	4 ± 13	0	-	0	0	0	-	0	0	0
Phoenix Head Glacier		427 ± 880	115 ± 230	0	0	5 ± 8	1022 ± 1109	20 ± 29	0	0	0	0	0	0 ± 1	0	0	0
Eclipse Sound		120 ± 193	0	0	0	7 ± 9	0	0	0	0	0	0	0	0	0	0	0
Cape Hatt Bay 7		-	0	0	-	-	7 ± 11	1 ± 3	-	-	0	0	-	-	0	0	-
Bay 9		42 ± 22	0	0	-	0	5 ± 9	1 ± 3	-	0	0	0	-	0	0	0	-
Bay 10		102 ± 129	1 ± 5	0	-	1 ± 2	1 ± 3	0	-	0	0	0	-	0	0	0	-
Bay 11		95 ± 59	0	0	-	13 ± 7	5 ± 14	1 ± 3	-	0	0	0	-	0	0	0	-
Scott Inlet		-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0
Cunningham Inlet	Inner	-	22	0	0	-	0	0	0	-	0	17 ± 38	0	-	0	0	0
	Outer	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0
Aston Bay		137 ± 161	29	46 ± 73	0	0	10 ± 13	0	0	1 ± 2	0	0	0	0	0	0	0
Brodeur Peninsula		1 ± 3	13 ± 22	0	0	284 ± 425	82 ± 127	0	0	575 ± 774	57 ± 50	7 ± 11	0	1 ± 3	6 ± 11	0	0
Little Cornwallis Island		166 ± 150	0	13 ± 23	-	0	0	0	-	5 ± 10	0	0	-	116 ± 187	4 ± 8	0	-
Byam Martin Island		1265 ± 2526	0	0	0	10 ± 18	0	0	0	273 ± 359	0	0	0	34 ± 51	32 ± 55	0	0
Richardson Point		13 ± 27	0	0	0	0	105 ± 67	4 ± 8	0	27 ± 27	342 ± 484	8 ± 10	0	0	228 ± 322	0	0
Graham Moore Bay		86 ± 91	0	2 ± 7	0	2 ± 4	61 ± 126	0	3 ± 8	7 ± 9	0	5 ± 9	22 ± 39	0	4 ± 8	0	0
Bridport Inlet[a]	1	155 ± 262	0	0	0	0	0	10 ± 19	0	128 ± 226	0	0	0	2 ± 4	0	0	0
	2	-	0	0	0	-	76	0	10	-	0	0	0	-	0	0	0
	3	2 ± 5	0	0	0	0	0	0	0	22 ± 29	0	0	0	0	0	0	0
Creswell Bay	Inner	-	0	6 ± 9	0	-	0	6 ± 16	14 ± 25	-	0	0	0	-	0	0	0
	Outer	-	23 ± 41	22 ± 52	22 ± 39	-	5 ± 12	0	8 ± 15	-	19 ± 27	2 ± 6	5 ± 9	-	0	0	0
Beaufort Bay		82 ± 127	0	0	6 ± 11	63 ± 121	114 ± 197	0	0	1 ± 1	0	0	0	0	0	0	0
Bellot Strait		57 ± 70	57	6 ± 11	-	21 ± 23	1102	0	-	69 ± 71	1140	0	-	0	0	0	-
Mean of all sites		454 ± 1838	20 ± 116	4 ± 22	3 ± 15	34 ± 205	43 ± 240	2 ± 9	2 ± 8	75 ± 344	14 ± 106	1 ± 7	2 ± 12	13 ± 65	4 ± 37	0	0

[a] Intertidal Transect 1 includes Transect 2; Intertidal Transect 3 includes Transect 4.

Table 25. Summary of data on the physical environment of the intertidal habitat, including number of samples taken during low, mid and high tide levels, at study sites in eastern Lancaster Sound, and in the arctic archipelago.

Location[a]	Date		No. Samples[b]			Temperature °C			Salinity			Slope[c]			Substrate[d] Rock			Cobble			Pebble			Sand			Silt/Clay		
	Day/mo.	Yr	LW ± 1:50[f]	Mid	HW ± 1:50	LW ± 1:50	Mid	HW ± 1:50	LW ± 1:50	Mid	HW ± 1:50	LW ± 1:50	Mid	HW ± 1:50	LW ± 1:50	Mid	HW ± 1:50	LW ± 1:50	Mid	HW ± 1:50	LW ± 1:50	Mid	HW ± 1:50	LW ± 1:50	Mid	HW ± 1:50	LW ± 1:50	Mid	HW ± 1:50
Philpots Island	23/08	78	-	6	7	-	0.9	2.4	-	19.7	22.9	-	0.16	0.20	-	7	11	-	17	31	-	19	9	-	38	31	-	0	0
Phoenix Head Glacier	30/08	78	-	13	12	-	0.8	0.6	-	19.9	19.9	-	0.14	0.14	-	27	24	-	37	30	-	31	22	-	3	23	-	0	0
Navy Board Inlet	04/09	78	-	8	5	-	-0.4	0.4	-	28.3	26.2	-	0.17	0.15	-	23	4	-	33	19	-	6	38	-	30	38	-	0	0
Croker Bay	02/09	78	-	5	4	-	-0.3	-0.9	-	13.0	15.6	-	0.15	0.14	-	5	4	-	65	41	-	16	9	-	1	16	-	0	0
Eclipse Sound	10, 11/09	78	8	9	6	2.9	3.5	1.4	18.9	19.8	19.3	0.15	0.11	0.11	14	14	19	28	33	20	41	14	17	14	12	28	0	1	0
Cape Hart Bay 9	17/08	81	10	-	-	4.3	-	-	21.4	-	-	0.13	-	-	33	-	-	40	-	-	24	-	-	3	-	-	0	-	-
Bay 10	19/08	81	10	-	-	4.4	-	-	13.8	-	-	0.11	-	-	61	-	-	10	-	-	6	-	-	22	-	-	2	-	-
Bay 11	17/08	81	10	-	-	5.1	-	-	23.6	-	-	0.10	-	-	26	-	-	28	-	-	25	-	-	23	-	-	0	-	-
Allen Bay	31/08	77	4	11	5	0.2	0.4	0.4	29.0	29.4	30.2	0.17	0.13	0.30	38	45	12	59	47	86	3	0	0	0	0	0	0	0	0
Aston Bay	06, 07/08	77	4	9	4	6.4	8.9	7.8	13.5	17.7	9.8	0.16	0.09	0.13	85	25	59	10	44	38	6	3	1	0	0	0	0	24	0
Brodeur Peninsula	20, 21/08	77	5	1	6	5.6	2.0	1.1	27.6	26.5	25.7	0.60	-	0.10	0	0	0	1	0	18	0	0	10	98	100	68	0	0	0
Little Cornwallis Island	12-15/08	77	10	6	5	2.4	2.1	2.2	26.0	25.8	26.8	0.13	0.18	0.15	26	38	3	38	45	45	22	10	48	3	0	0	10	0	0
Byam Martin Island	25/08	77	10	-	5	3.2	-	3.8	21.4	-	20.5	0.07	-	0.05	0	-	0	8	-	0	28	-	0	45	-	100	20	-	0
Richardson Point	18/08	77	5	5	-	6.6	4.0	-	27.5	27.7	-	0.05	0.06	-	0	0	-	0	0	-	0	0	-	100	100	-	0	0	-
Graham Moore Bay	10/08	77	11	4	-	4.2	3.1	-	21.2	21.4	-	0.12	0.20	-	0	0	-	25	50	-	0	0	-	73	50	-	0	0	-
Bridport Inlet[e] 1,2	14, 23/08	77	9	-	3	-	-	-	-	-	-	0.19	-	0.08	34	-	0	22	-	0	0	-	0	8	-	50	35	-	50
3,4	21, 25/08	77	3	3	3	-	-	-	-	-	-	0.17	0.10	0.13	0	0	0	2	0	0	0	0	67	33	100	33	63	0	0
Resolute Bay	29/08, 02/09	77	3	4	8	4.7	3.0	2.1	7.7	21.1	22.8	0.09	0.12	0.15	52	44	20	17	25	30	0	6	29	30	25	23	0	0	0
Ballot Strait	25/07	77	-	1	6	-	6.0	4.4	-	11.2	19.3	-	0.14	0.13	-	50	9	-	50	23	-	0	19	-	0	33	-	0	8

[a] See Fig. 1.
[b] No samples were collected where dash (-) is indicated.
[c] Ratio of drop/distance from waterline over a distance of 1 metre.
[d] Values are expressed as mean of % of sampling quadrat covered by the substrate type. Percent contributions of boulders and/or bedrock are not shown.
[e] 1,2,3,4 = Transects 1,2,3,4.
[f] Herein.

Table 26. Biomass and density of total amphipods and densities of Gammarus setosus and total Onisimus amphipods from intertidal habitats during low, mid and high tide levels in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago. Data are expressed as mean ± standard deviation and are based on samples each covering 0.25 m^2 (see Table 25 for n values).

	Biomass ($g \cdot m^{-2}$)			Density ($no. \cdot m^{-2}$)								
	Total Amphipod			Total Amphipod			Gammarus setosus			Onisimus (total)[a]		
Location	LW ± 1:50[c]	Mid	HW ± 1:50	LW ± 1:50	Mid	HW ± 1:50	LW ± 1:50	Mid	HW ± 1:50	LW ± 1:50	Mid	HW ± 1:50
Philpots Island	-	0.79 ± 1.17	0.19 ± 0.37	-	61 ± 84	5 ± 4	-	11 ± 13	2 ± 2	-	51 ± 72	2 ± 5
Phoenix Head Glacier	-	15.27 ± 31.51	0.50 ± 0.56	-	814 ± 1111	20 ± 28	-	804 ± 1108	18 ± 28	-	8 ± 10	2 ± 4
Navy Board Inlet	-	0.05 ± 0.08	0.06 ± 0.09	-	3 ± 3	2 ± 4	-	0	0	-	3 ± 3	2 ± 4
Croker Bay	-	0.10 ± 0.09	0.01 ± 0.02	-	36 ± 27	3 ± 4	-	34 ± 26	1 ± 2	-	2 ± 2	2 ± 2
Eclipse Sound	2.60 ± 2.87	0.52 ± 0.61	0.42 ± 0.63	316 ± 253	34 ± 35	21 ± 36	298 ± 244	29 ± 29	19 ± 36	16 ± 9	5 ± 8	3 ± 7
Cape Hatt Bay 9	1.35 ± 0.85	-	-	43 ± 29	-	-	42 ± 22	-	-	0	-	-
Bay 10	1.20 ± 1.40	-	-	108 ± 135	-	-	102 ± 129	-	-	1 ± 2	-	-
Bay 11	1.85 ± 1.42	-	-	112 ± 68	-	-	95 ± 59	-	-	13 ± 7	-	-
Allen Bay	15.41 ± 30.70	1.48 ± 4.61	0.05 ± 0.04	1668 ± 3315	23 ± 34	6 ± 2	0	8 ± 24	0	1663 ± 3318	8 ± 11	3 ± 3
Aston Bay	1.38 ± 2.25	2.83 ± 2.56	0.34 ± 0.43	74 ± 90	226 ± 173	41 ± 44	70 ± 87	211 ± 187	40 ± 42	3 ± 2	13 ± 26	1 ± 2
Broomm Peninsula	14.69 ± 11.28	25.75	0.80 ± 1.82	1493 ± 999	3244	35 ± 72	0	12	0	1493 ± 999	3232	5 ± 8
Little Cornwallis Island	17.11 ± 12.92	8.95 ± 7.49	0	588 ± 290	269 ± 116	0	204 ± 152	243 ± 105	0	334 ± 280	23 ± 27	0
Byam Martin Island	9.78 ± 7.95	-	0.01 ± 0.01	2856 ± 2459	-	2 ± 4	1897 ± 2932	-	2 ± 2	954 ± 858	-	1 ± 2
Richardson Point	0.38 ± 0.27	0.17 ± 0.17	-	80 ± 52	71 ± 72	-	6 ± 8	20 ± 38	-	74 ± 57	50 ± 38	-
Graham Moore Bay	0.55 ± 0.53	0.53 ± 0.49	-	112 ± 83	88 ± 136	-	90 ± 85	75 ± 118	-	19 ± 13	11 ± 17	-
Bridport Inlet[b] 1,2	4.92 ± 8.31	-	0.08 ± 0.14	673 ± 1136	-	5 ± 9	207 ± 287	-	0	465 ± 856	-	5 ± 9
3,4	1.45 ± 1.80	0.11 ± 0.14	0.04 ± 0.07	60 ± 47	13 ± 12	3 ± 5	7 ± 6	0	0	52 ± 39	13 ± 12	3 ± 5
Brentford Bay	22.22 ± 9.29	2.10 ± 2.39	5.72 ± 5.71	423 ± 76	77 ± 110	83 ± 82	233 ± 214	74 ± 111	30 ± 32	176 ± 242	2 ± 4	53 ± 68
Bellot Strait	-	0.66	1.15 ± 1.16	-	208	185 ± 128	-	100	50 ± 73	-	108	135 ± 106
All sites	7.69 ± 11.65	4.01 ± 13.55	0.88 ± 2.47	841 ± 1525	519 ± 2681	33 ± 69	379 ± 1223	464 ± 2665	13 ± 31	453 ± 994	53 ± 350	18 ± 50

[a] Includes Onisimus litoralis, O. glacialis, O. nansenl and unidentified, damaged or juvenile Onisimus.
[b] 1,2,3,4 = Transects 1,2,3,4.
[c] Hr:min.

Table 27. Density and biomass of total amphipods in the intertidal habitats of the study sites in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago. Data are expressed as mean ± standard deviation and are based on samples each covering 0.25 m^2 (see Table 25 for n values).

Location	Tide levels	Mean density ($no.m^{-2}$)	Mean biomass ($g.m^{-2}$)	Dominant
Philpots Island	mid, high	31 ± 62	0.47 ± 0.86	Onisimus litoralis
Phoenix Head Glacier	mid, high	433 ± 884	8.18 ± 23.52	Gammarus setosus
Navy Board Inlet	mid, high	3 ± 3	0.05 ± 0.08	O. litoralis
Croker Bay	mid, high	21 ± 26	0.06 ± 0.08	G. setosus
Eclipse Sound	low, mid, high	129 ± 202	1.14 ± 1.99	G. setosus
Cape Hatt Bay 9	low	43 ± 29	1.35 ± 0.85	G. setosus
Bay 10	low	108 ± 135	1.20 ± 1.40	G. setosus
Bay 11	low	112 ± 68	1.85 ± 1.42	G. setosus
Allen Bay	low, mid, high	348 ± 1481	3.91 ± 13.97	O. glacialis
Aston Bay	low, mid, high	147 ± 156	1.91 ± 2.33	G. setosus
Brooman Peninsula	low, mid, high	910 ± 1197	8.67 ± 11.16	O. glacialis
Little Cornwallis Island	low, mid, high	357 ± 319	10.70 ± 11.80	G. setosus
Byam Martin Island	low, high	1905 ± 2414	6.52 ± 7.96	G. setosus
Richardson Point	low, mid	76 ± 59	0.27 ± 0.24	Onisimus juvenile
Graham Moore Bay	low, mid	105 ± 95	0.55 ± 0.50	G. setosus
Bridport Inlet[a] 1,2	low, high	506 ± 1014	3.71 ± 7.42	Onisimus spp.
3,4	low, mid, high	25 ± 36	0.53 ± 1.13	O. glacialis
Brentford Bay	low, mid, high	149 ± 164	8.05 ± 9.28	G. setosus
Bellot Strait	mid, high	189 ± 117	1.08 ± 1.08	O. glacialis

[a] 1, 2, 3, 4, = Transects 1, 2, 3, 4.

Table 28. Estimated growth rates for Gammarus setosus at study sites in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago.

Location	Date	Mean length[a] (mm)			Growth rate (mm)		Reference
		0+	1+	2+	1st yr	2nd yr	
Phoenix Head Glacier	30/08/78	5	8	14	3	6	present study
Eclipse Sound	10, 11/09/78	4	12	-	8	-	present study
Cape Hatt[b]	17, 19/08/81	5	11	-	6	-	present study
Cape Hatt[b]	24/08/82	5	12	-	7	-	Cross and Martin (1983)
Aston Bay	6,7/08/77	3	7	12	4	5	present study
Brentford Bay	29/08, 2/09/77	5	9	15	4	6	present study
Arctic[c]	-/07/08/50-66	4	11	19	7	8	Steele and Steele (1970)

[a] Mean lengths of cohorts shown in Fig. 10.
[b] Only control data from unoiled bays were used.
[c] Labrador to Ellesmere Island. Approximate values only.
- means too few data.

Table 29. Variables of the physical environment used in multiple regression analyses of the abundance of major intertidal amphipods.

Variable	Definition and Units	Range of values
Tide	High water = 0 h, Low water = 6 h	0-6
Slope	Ratio of drop/distance from waterline over a distance of 1 metre	0.02-0.34
Rock	% of sampling quadrat covered by rocks >5 cm in diameter	0-100
Cobble	% of sampling quadrat covered by cobble 1 to 5 cm in diameter	0-100
Pebble	% of sampling quadrat covered by pebbles <1 cm in diameter	0-100
Sand	% of sampling quadrat covered by sand	0-100
Temperature	Temperature of the water (°C) at the time of sampling	-1.5 to +12.0
Salinity	Salinity at the time of sampling	1.0-30.3
Exposure	Wave exposure index after Baarsdeth (1970)	3-81
Baffin	Northeast Baffin Island and Lancaster Sound[a]	0-1
Eclipse	Eclipse Sound[a]	0-1
Barrow	Barrow and Crozier Straits[a]	0-1
Viscount	Viscount Melville Sound[a]	0-1
Boothia	North Boothia Peninsula[a]	0-1

[a] Coded as 1 if the sample was collected at this site; 0 if not.

Table 30. Pearson product-moment correlation matrix of measurements of physical variables[a] from intertidal habitats in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago. Significance levels shown by asterisks (* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$).

	Tide	Slope	Rock	Cobble	Pebble	Sand	Temperature	Salinity	Exposure	Baffin	Eclipse	Barrow	Viscount	Boothia
Tide	1.000													
Slope	-0.201 **	1.000												
Rock	0.032	0.157 *	1.000											
Cobble	-0.160 *	0.336 ***	0.039	1.000										
Pebble	-0.117	0.099	-0.211 **	-0.046	1.000									
Sand	0.110	-0.336 ***	-0.507 ***	-0.603 ***	-0.299 ***	1.000								
Temperature	0.249 ***	-0.334 ***	0.020	-0.227 **	-0.193 **	0.177 *	1.000							
Salinity	0.031	-0.008	-0.243 ***	0.114	0.059	0.068	-0.191 **	1.000						
Exposure	-0.005	-0.044	-0.346 ***	-0.128	0.028	0.343 ***	-0.386 ***	0.058	1.000					
Baffin	-0.322 ***	0.212 **	-0.001	0.095	0.186 **	-0.101	-0.491 ***	-0.102	0.576 ***	1.000				
Eclipse	0.116	-0.050	-0.031	-0.060	0.133	-0.078	0.010	-0.138	-0.011	-0.211 **	1.000			
Barrow	0.101	0.076	0.278 ***	0.248 ***	-0.157 *	-0.299 ***	0.185 **	0.244 ***	-0.609 ***	-0.441 ***	-0.243 ***	1.000		
Viscount	0.328 ***	-0.298 ***	-0.400 ***	-0.316 ***	-0.161 *	0.570 ***	0.255 ***	0.062	0.467 ***	-0.284 ***	-0.156 *	-0.326 ***	1.000	
Boothia	-0.203 **	-0.010	0.095	-0.070	0.036	-0.018	0.105	-0.165 *	-0.461 ***	-0.217 **	-0.119	-0.249 ***	-0.160 *	1.000

[a] Physical variables are described in Table 29. Analysis was based on 202 samples.

Table 31. Multiple regression analyses[a] of abundance of major intertidal taxa in relation to physical variables[b] from the study sites in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago. Nominal significance levels shown by asterisks (* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$). Variables denoted by '-' were not of significant value as predictors of abundance ($P > 0.05$) and were excluded from the equations.

	Total Amphipoda	*Gammarus setosus*	*Onisimus* (total)[c]	*Onisimus litoralis*	*Onisimus glacialis*	*Onisimus nanseni*	*Onisimus* juvenile
Constant (Y-intercept)	1.2553	5.0359	1.0647	-1.0506	0.4331	0.1037	0.8815
Tide	0.6958 ***	0.4117 ***	0.5774 ***	0.3160 ***	0.3178 ***	0.2790 ***	0.3013 ***
Slope	-	-	-	-	-	-2.9929 *	-
Rock	-	-	-0.2986 ***	-	-0.1726 **	-	-0.1158 ***
Cobble	-	-	-0.1957 **	-	-0.1952 ***	-	-
Pebble	-	-	-	-	-	-	-
Sand	-0.1083 *	-0.3797 ***	-	0.1885 ***	-	-	-
Temperature	0.1724 **	-	-	-	0.1597 **	-0.1224 ***	-
Salinity	-	-0.0826 ***	-	-	-	-	-
Exposure	-	-0.0228 ***	-	0.0180 ***	0.0648 ***	-	-0.0171 ***
Baffin	-	-	-	-	-4.8683 ***	-	-
Eclipse	-0.8746 *	-	-0.8804 *	-	-4.1841 ***	-	-1.0440 **
Barrow	-	-1.2031 **	0.8176 **	-	-1.0658 **	0.8359 ***	-
Viscount	-	2.1388 ***	-	-2.2125 ***	-4.5956 ***	-	1.9287 ***
Boothia	1.3617 **	-	2.0203 ***	2.2414 ***	-	-	-
Multiple R	0.6465 ***	0.6460 ***	0.6462 ***	0.5561 ***	0.6765 ***	0.5185 ***	0.6499 ***
% of variance explained	41.8	41.7	41.8	30.9	45.8	26.9	42.2
SE of estimate	1.8499	1.8743	1.7164	1.3724	1.4214	1.1901	1.3608

[a] The regression coefficient of each variable that entered the equation is shown, along with the constant (Y-intercept) and statistics describing the fit of the equation. Numbers transformed to log ($no.m^{-2} + 1$) prior to analysis.
[b] Physical variables are described in Table 29. Data are based on 202 samples.
[c] Includes *Onisimus litoralis*, *O. glacialis*, *O. nanseni* and unidentified, damaged or juvenile *Onisimus*.

Table 32. Pearson product-moment correlation coefficients of abundance[a] of major intertidal taxa with measurements of physical variables[b] from the study sites in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago. Significance levels shown by asterisks (* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$).

	Total Amphipoda	*Gammarus setosus*	*Onisimus* (total)[c]	*Onisimus litoralis*	*Onisimus glacialis*	*Onisimus nanseni*	*Onisimus* juvenile
Tide	0.567 ***	0.371 ***	0.492 ***	0.170 *	0.382 ***	0.408 ***	0.455 ***
Slope	-0.174 *	-0.030	-0.232 ***	-0.090	-0.250 ***	-0.125	-0.273 ***
Rock	0.108	0.229 **	-0.174 *	-0.103	-0.192 **	0.060	-0.182 **
Cobble	-0.101	0.038	-0.255 ***	-0.166 *	-0.304 ***	-0.078	-0.207 **
Pebble	-0.035	0.111	-0.060	0.059	-0.158 *	-0.064	-0.095
Sand	-0.032	-0.274 ***	0.258 ***	0.193 **	0.358 ***	-0.076	0.194 **
Temperature	0.324 ***	0.271 ***	0.225 **	0.008	0.250 ***	-0.027	0.315 ***
Salinity	-0.140 *	-0.302 ***	0.072	-0.145 *	0.101	0.077	0.087
Exposure	-0.138	-0.142 *	-0.086	-0.009	0.051	-0.138	-0.037
Baffin	-0.265 ***	-0.135	-0.311 ***	0.023	-0.310 ***	-0.206 **	-0.361 ***
Eclipse	-0.053	0.069	-0.118	0.085	-0.176 *	-0.120	-0.198 **
Barrow	0.074	-0.064	0.066	-0.172 *	0.085	0.276 ***	0.099
Viscount	0.186 **	0.120	0.266 ***	-0.114	0.361 ***	0.098	0.477 ***
Boothia	0.094	0.078	0.138	0.282 ***	0.050	-0.124	-0.016

[a] Numbers transformed to log ($no.m^{-2} + 1$) prior to analysis.
[b] Physical variables are described in Table 29. Data are based on 202 samples.
[c] Includes *Onisimus litoralis*, *O. glacialis*, *O. nanseni* and unidentified, damaged or juvenile *Onisimus*.

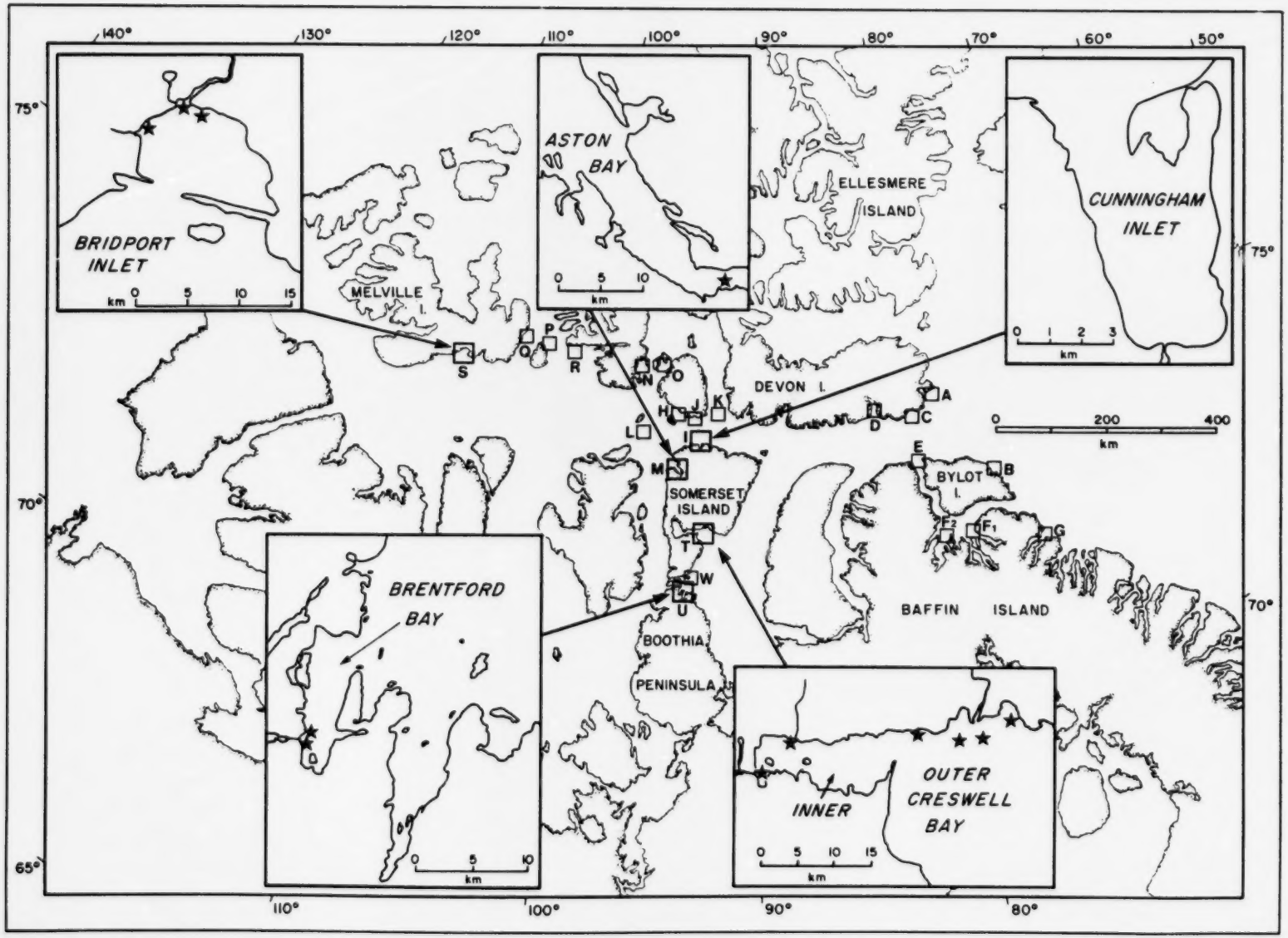

Fig. 1. Locations of nearshore sampling in the central and eastern Canadian high Arctic. See Table 1 for location names and sampling information.

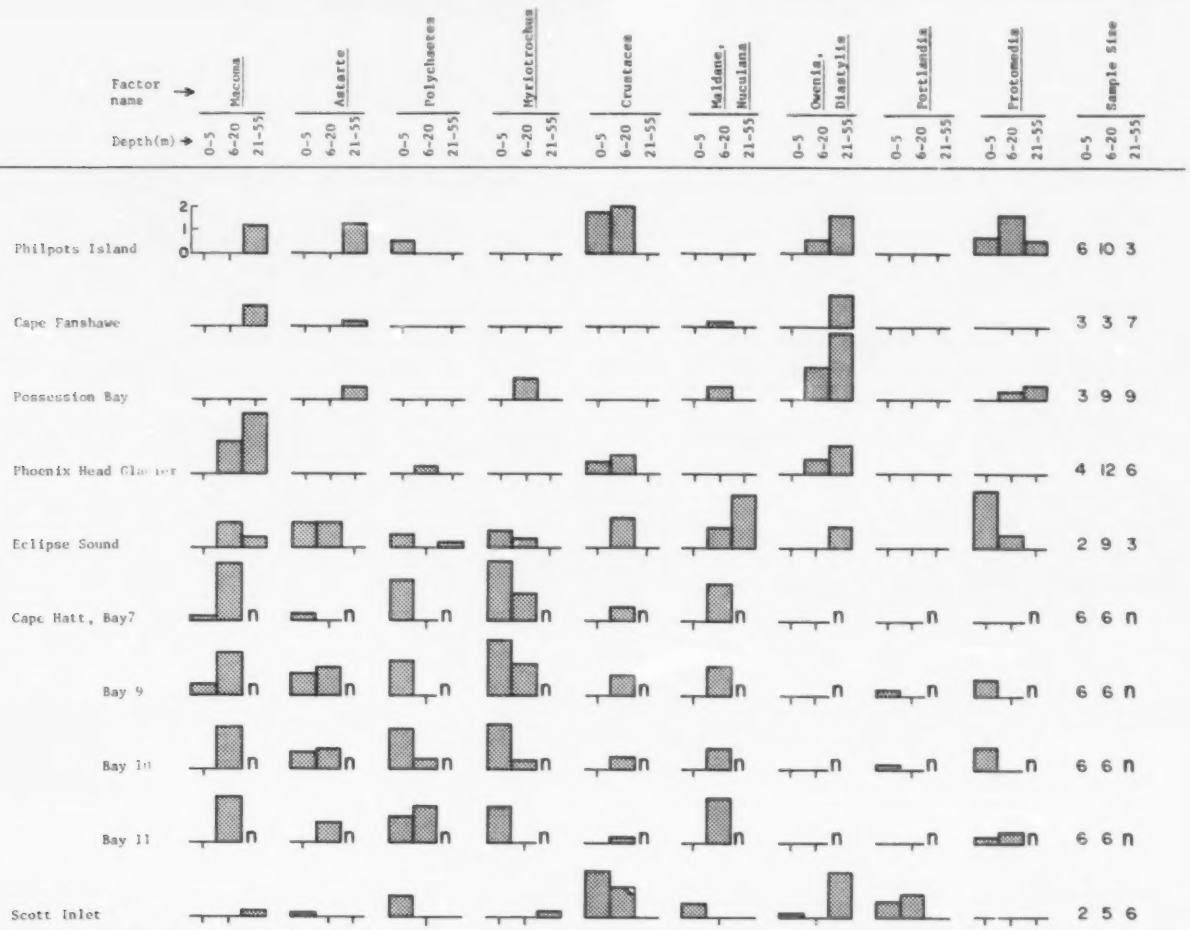

Fig. 2. Mean abundance of the nine species assemblages for various depth/area combinations in the central and eastern Canada high Arctic. Mean factor scores greater than 0.1 are shown. Negative scores less than -0.1 are indicated ( ). n means no sample.

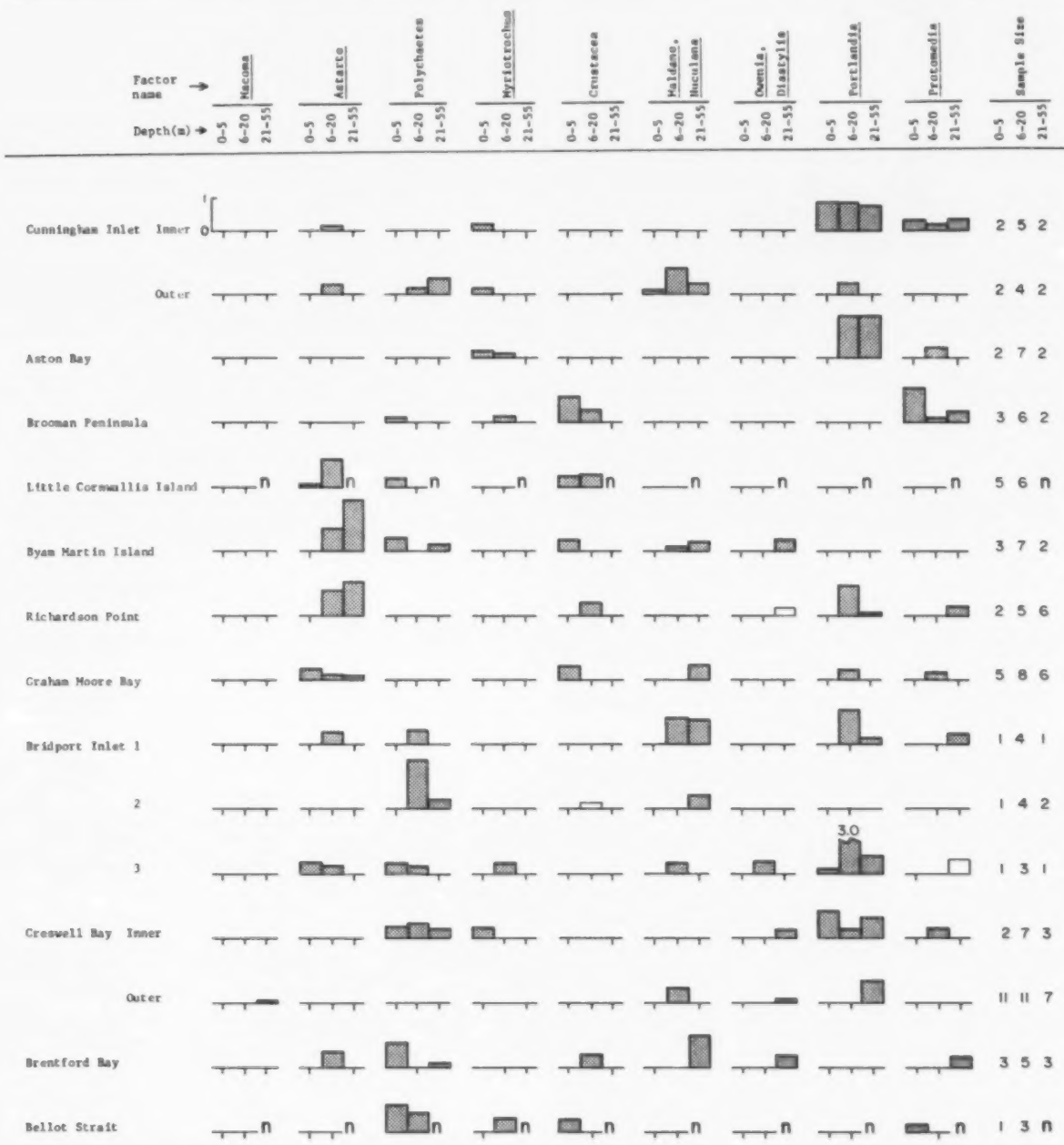

Fig. 2. Continued

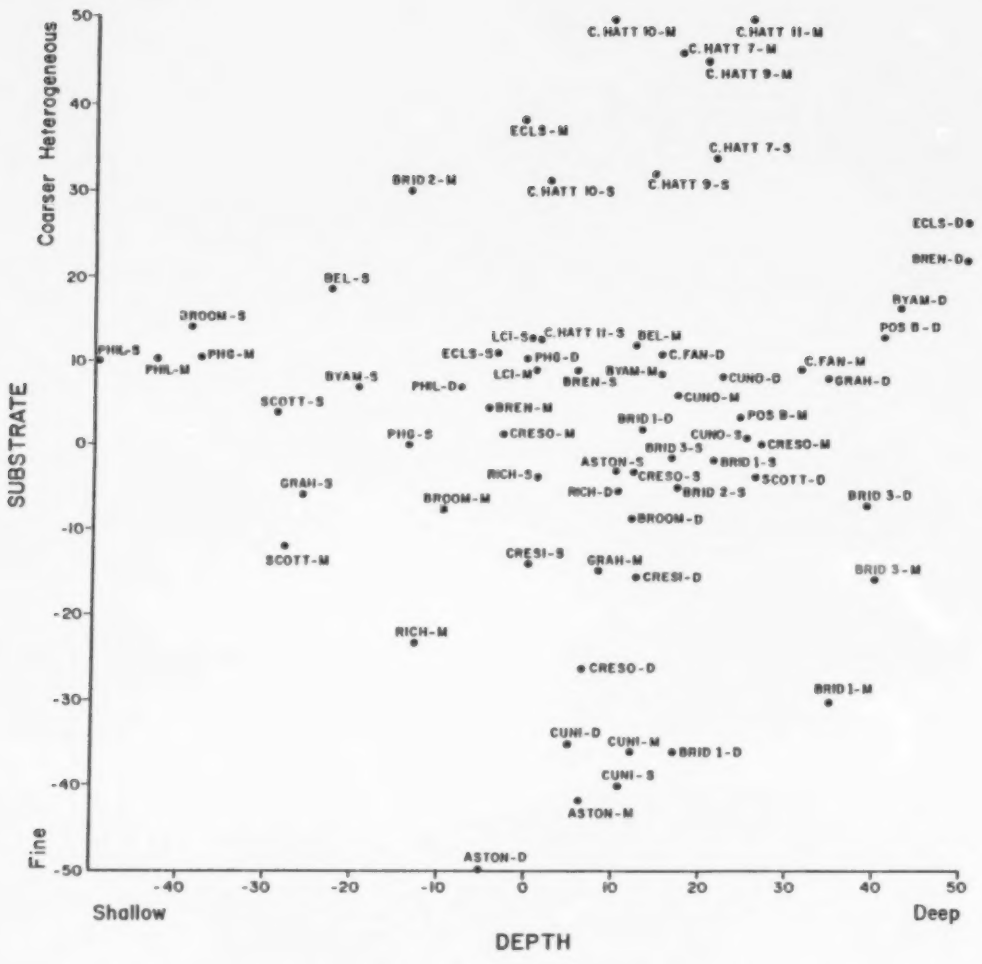

Fig. 3. Similarity of animal assemblages in 69 depth/area combinations from the eastern and central high Arctic to animal assemblages typically found in shallow and deep depths and in fine and coarse heterogeneous substrates. Plotted in this two-dimensional polar ordination are the geometric distances between each depth/area combination and those combinations representative of coarse, fine, deep and shallow. Geometric distance was calculated from euclidean distances computed from mean factor scores.

PHIL	Philpots Island	BROOM	Brooman Peninsula
C.FAN	Cape Fanshawe	LCI	Little Cornwallis Isl.
POSB	Possession Bay	BYAM	Byam Martin Island
PHG	Phoenix Head Glacier	RICH	Richardson Point
ECLS	Eclipse Sound	GRAH	Graham Moore Bay
C.HATT 7	Cape Hatt Bay 7	BRID 1	Bridport Inlet Trans. 1
C.HATT 9	Bay 9	BRID 2	Trans. 2
C.HATT 10	Bay 10	BRID 3	Trans. 3
C.HATT 11	Bay 11	CRESO	Creswell Bay (Outer)
SCOTT	Scott Inlet	CRESI	Creswell Bay (Inner)
CUNI	Cunningham Inlet (Inn)	BREN	Brentford Bay
CUNO	Cunningham Inlet (Out)	BEL	Bellot Strait
ASTON	Aston Bay		

- S = 0 to 5 m - M = 6 to 20 m - D = 21 to 55 m

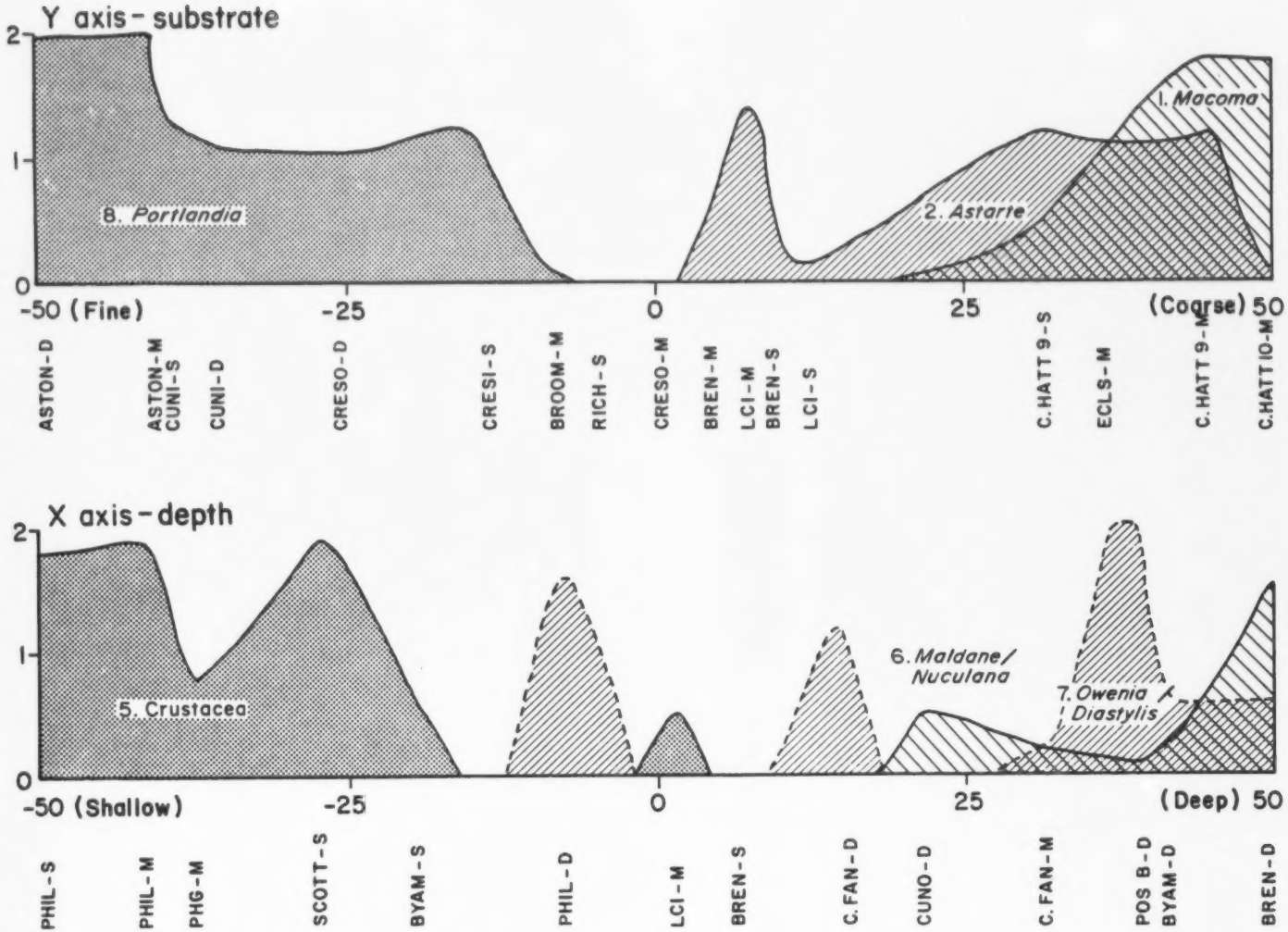

Fig. 4. Mean abundance of species assemblages characteristic of fine and coarser substrates and deep and shallow depths. The top figure shows the positions of depth/area combinations along the y-axis near x = 0 on Fig. 3. Also shown for these depth/area combinations is the abundance of assemblages representative of fine (left) and coarse heterogeneous (right) substrates. The bottom figure shows the positions of depth/area combinations along the x-axis near y = 0 and the abundance of assemblages representative of shallow (left) and deep (right) depths. See Fig. 3 for site abbreviations and depth range suffixes.

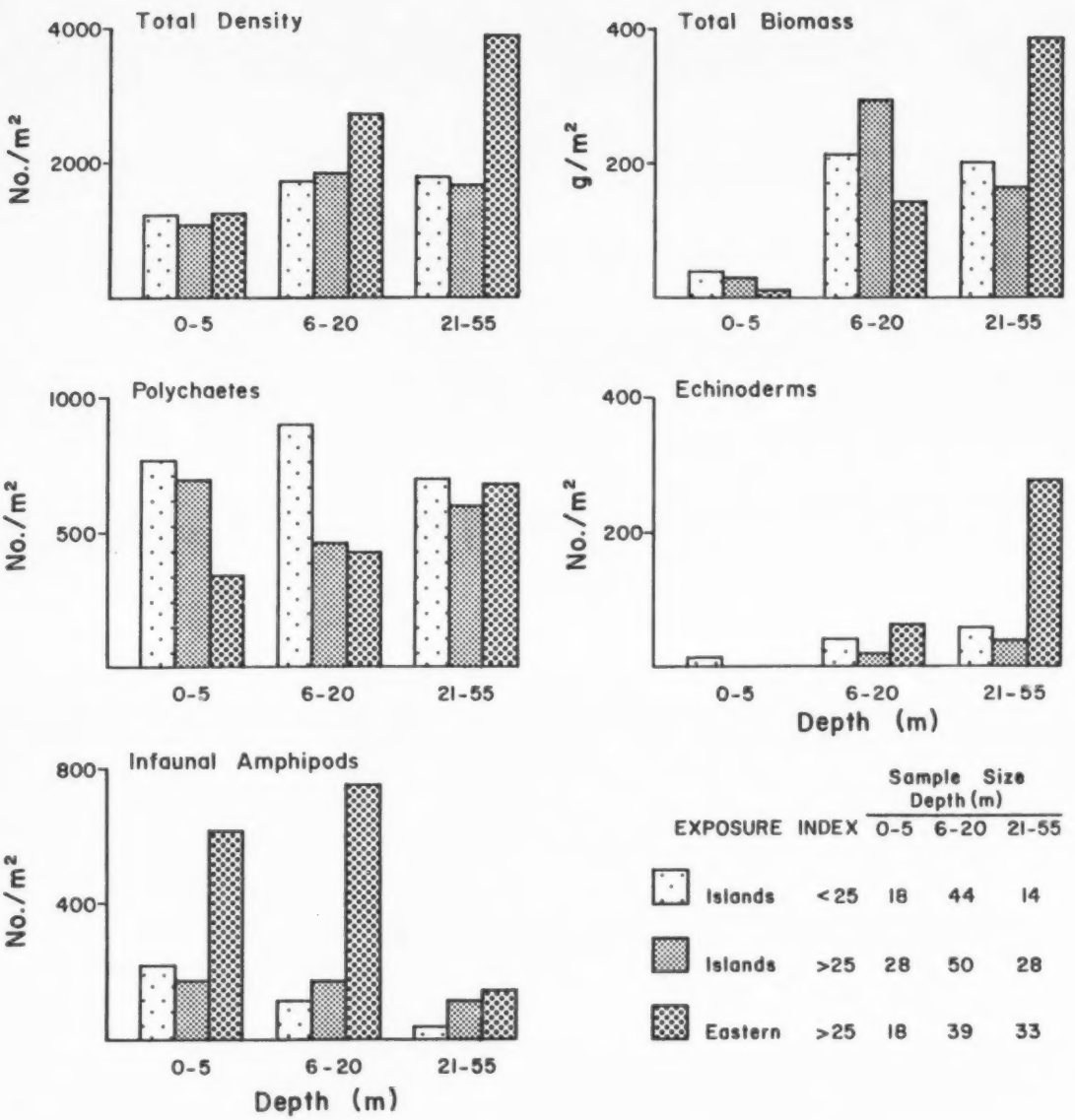

Fig. 5. Effect of exposure on the depth distributions of infaunal density and biomass, and the densities of selected taxa.

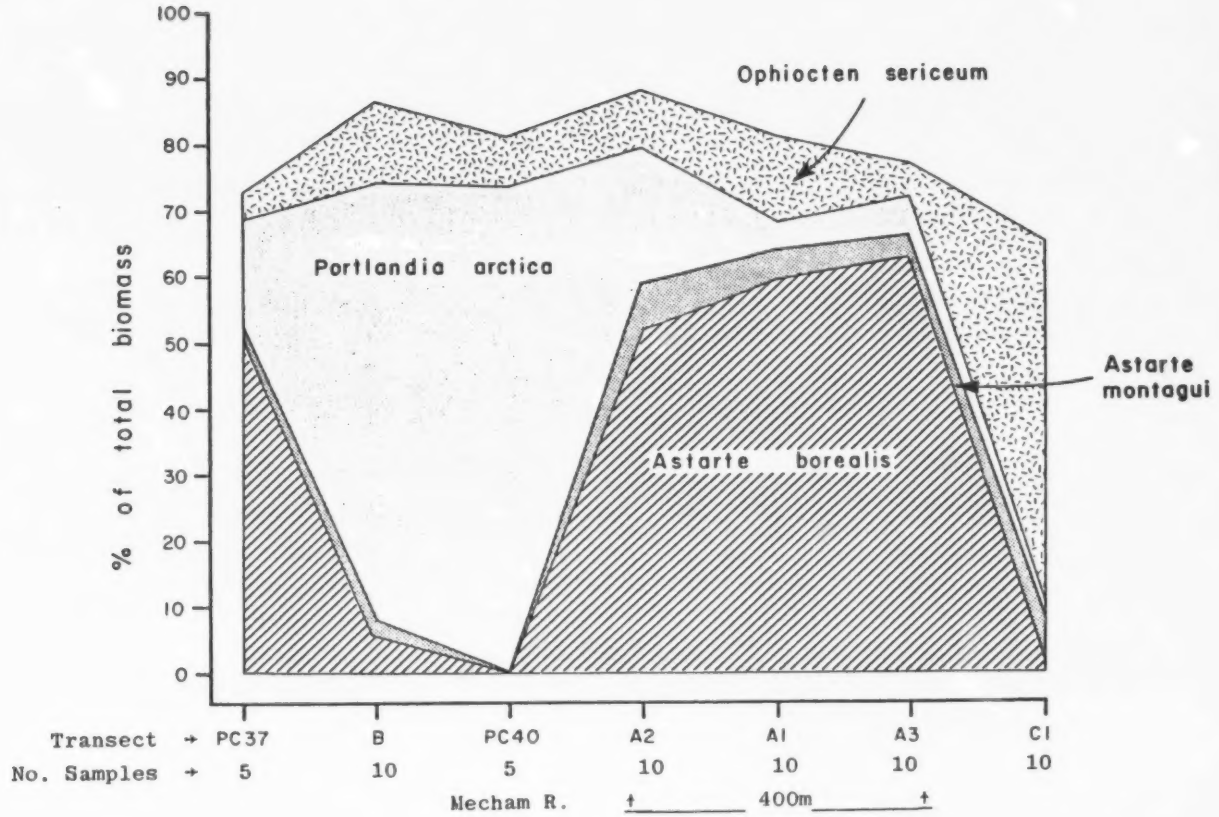

Fig. 6. Composition of the infaunal community by transect in Bridport Inlet, Melville Island. The distance between PC 37 and C 1 was approximately 12 km. Only airlift samples from depths of 3-15 m are considered. From Buchanan et al. (1977).

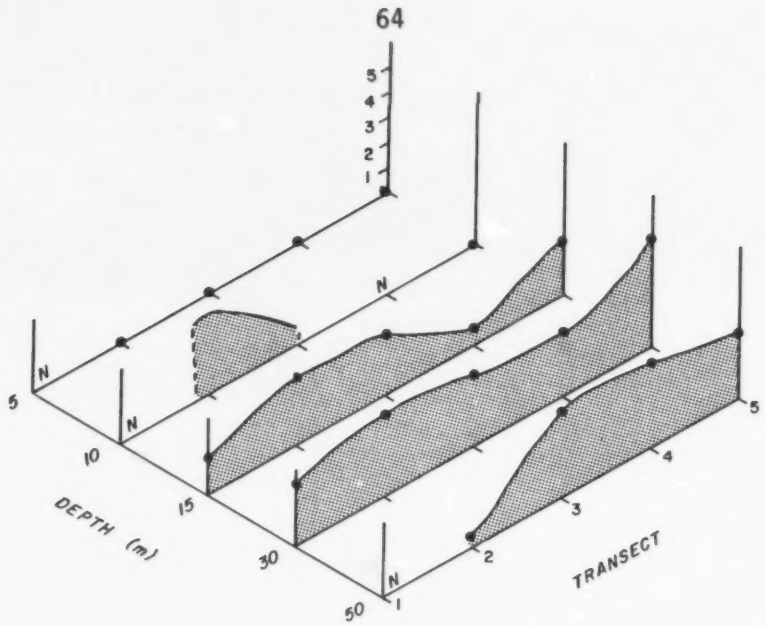

Fig. 7. Distribution of the Owenia/Diastylis assemblage in Possession Bay, Bylot Island. The transects were 200 m apart. The mean factor score for the seventh factor is shown for each sample. N = no data.

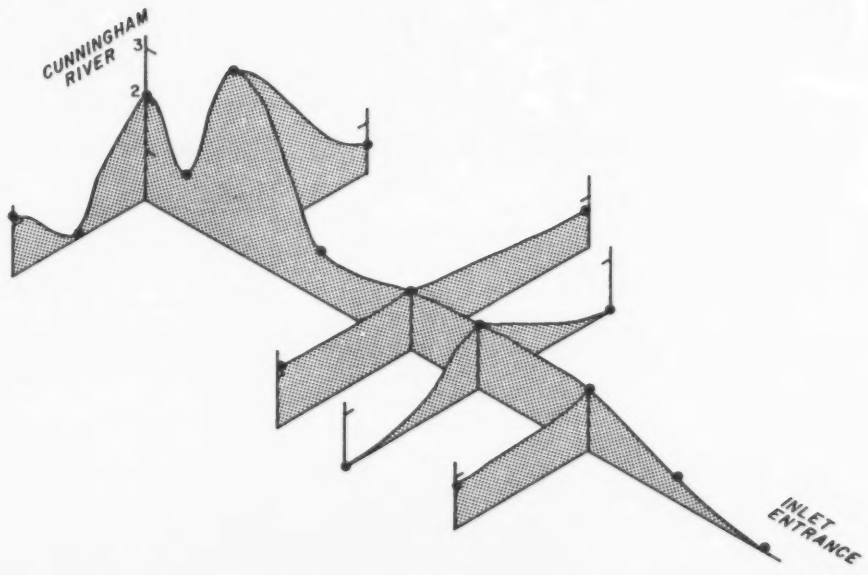

Fig. 8. Distribution of the Portlandia assemblage in Cunningham Inlet. The factor score for the eighth factor is shown for each sample taken in the inlet. Distance represented is about 3 by 12 km.

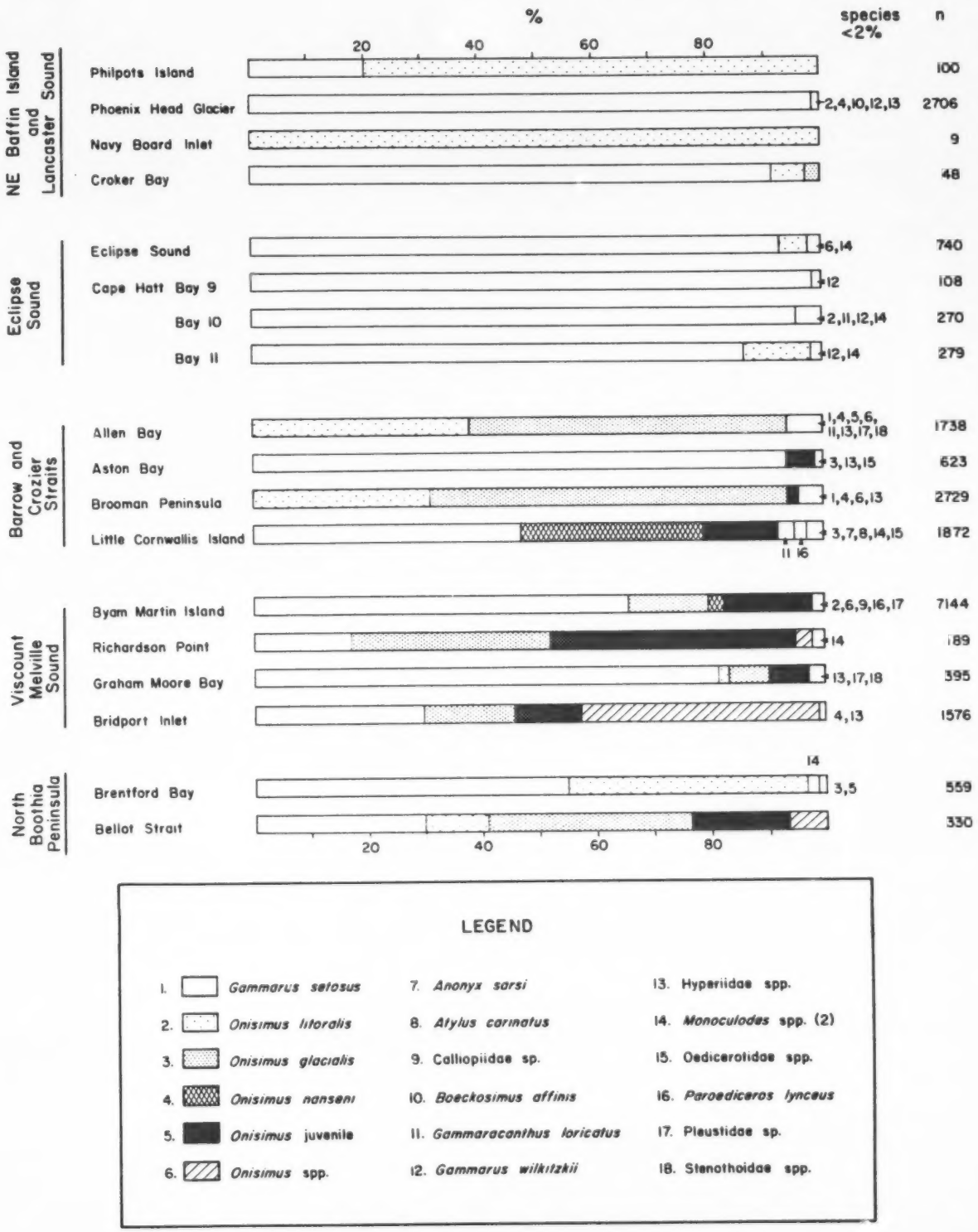

Fig. 9. Species composition of the intertidal amphipod community at the study sites in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago.

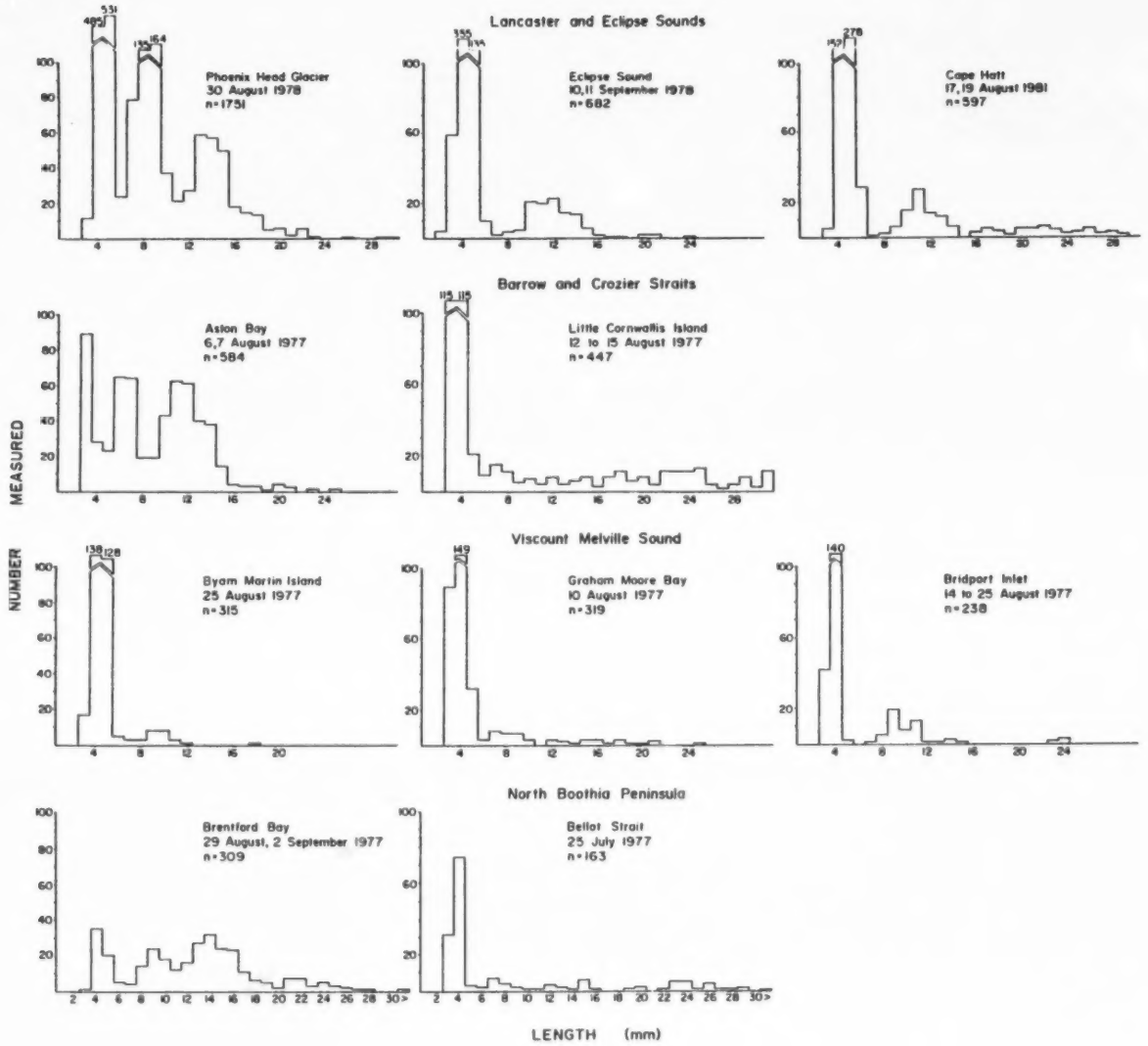

Fig. 10. Length-frequency histograms for Gammarus setosus from intertidal habitats in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago.

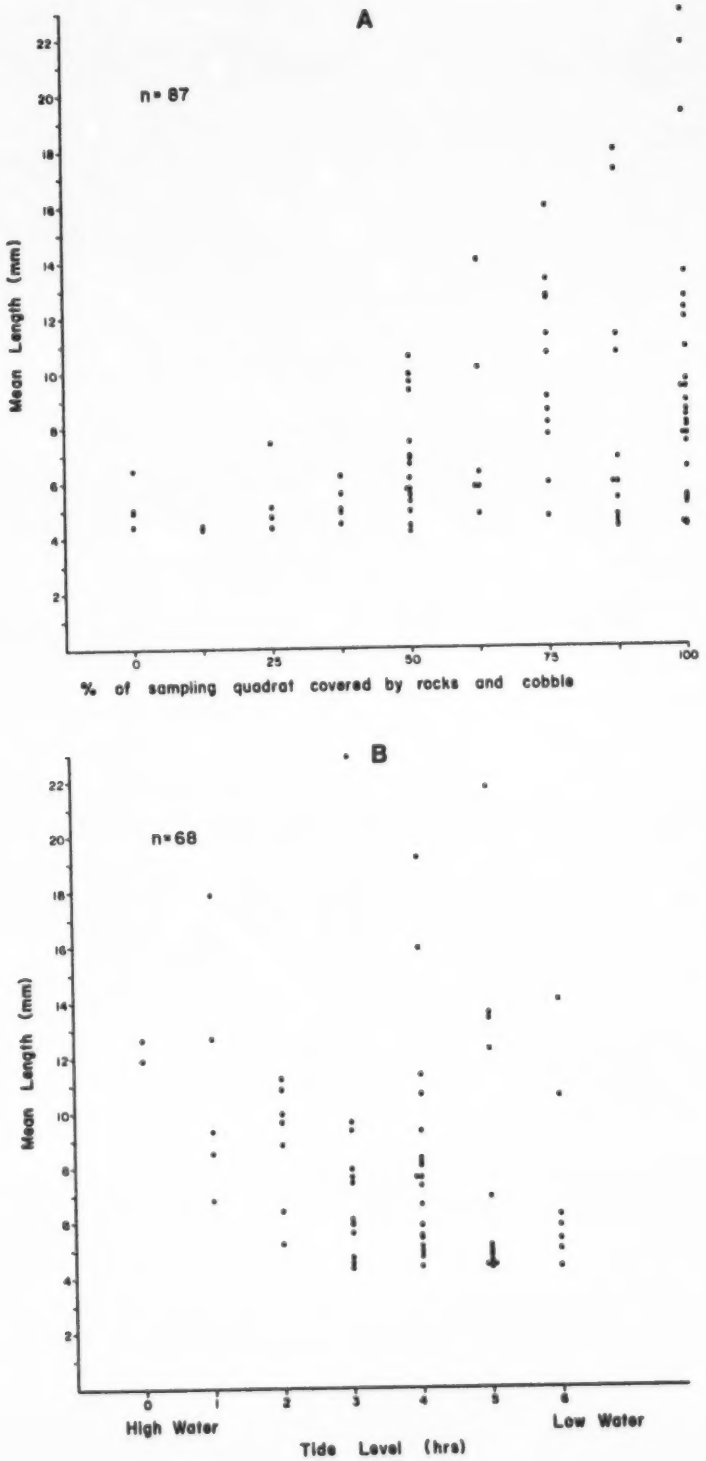

Fig. 11. Mean length of Gammarus setosus vs substrate (A) and tide levels (B) at study sites in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago. Each point represents one sample.

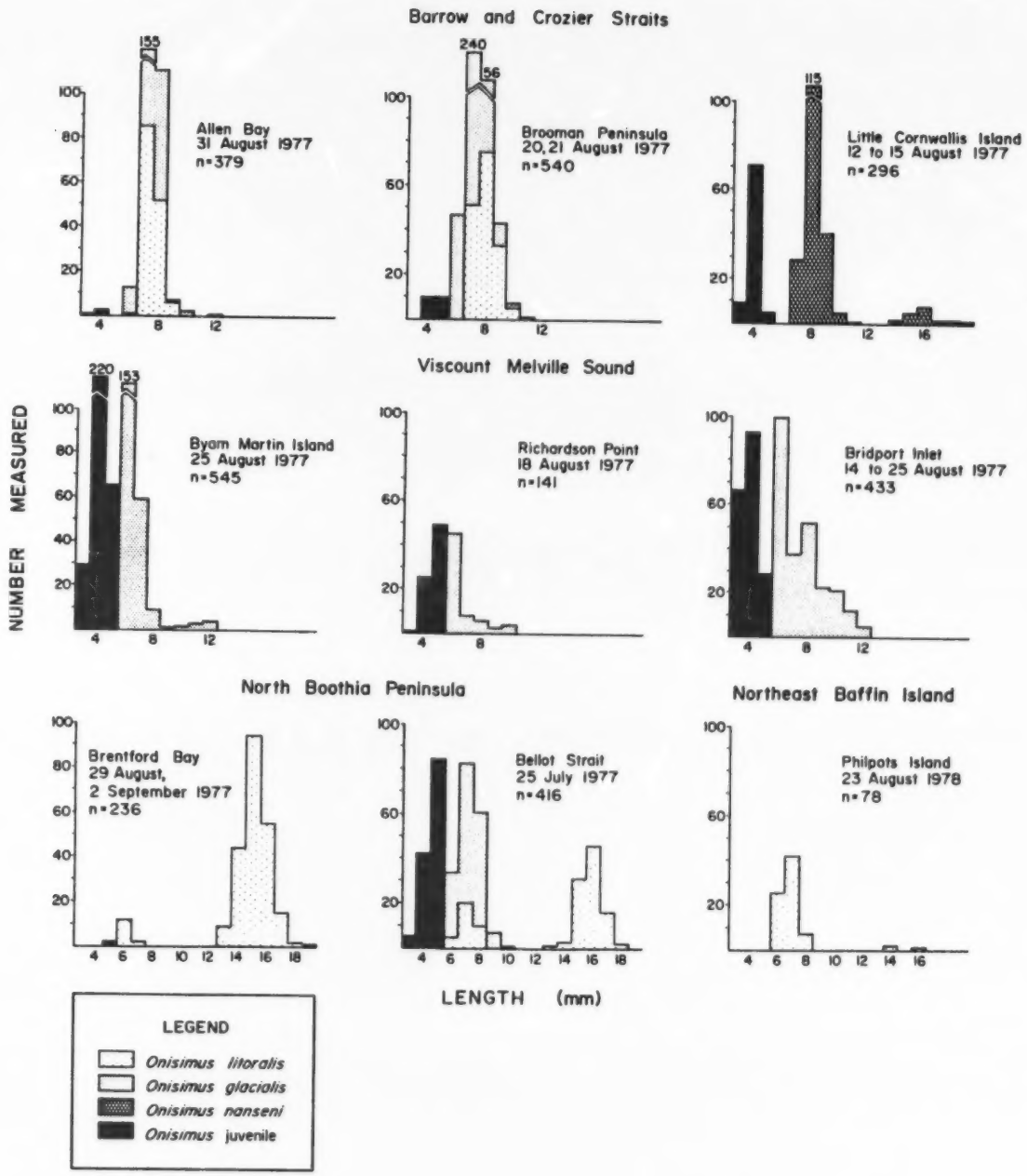

Fig. 12. Length-frequency histograms for amphipods of the genus Onisimus from intertidal habitats in eastern Lancaster Sound, northeast Baffin Island, and the central arctic archipelago.

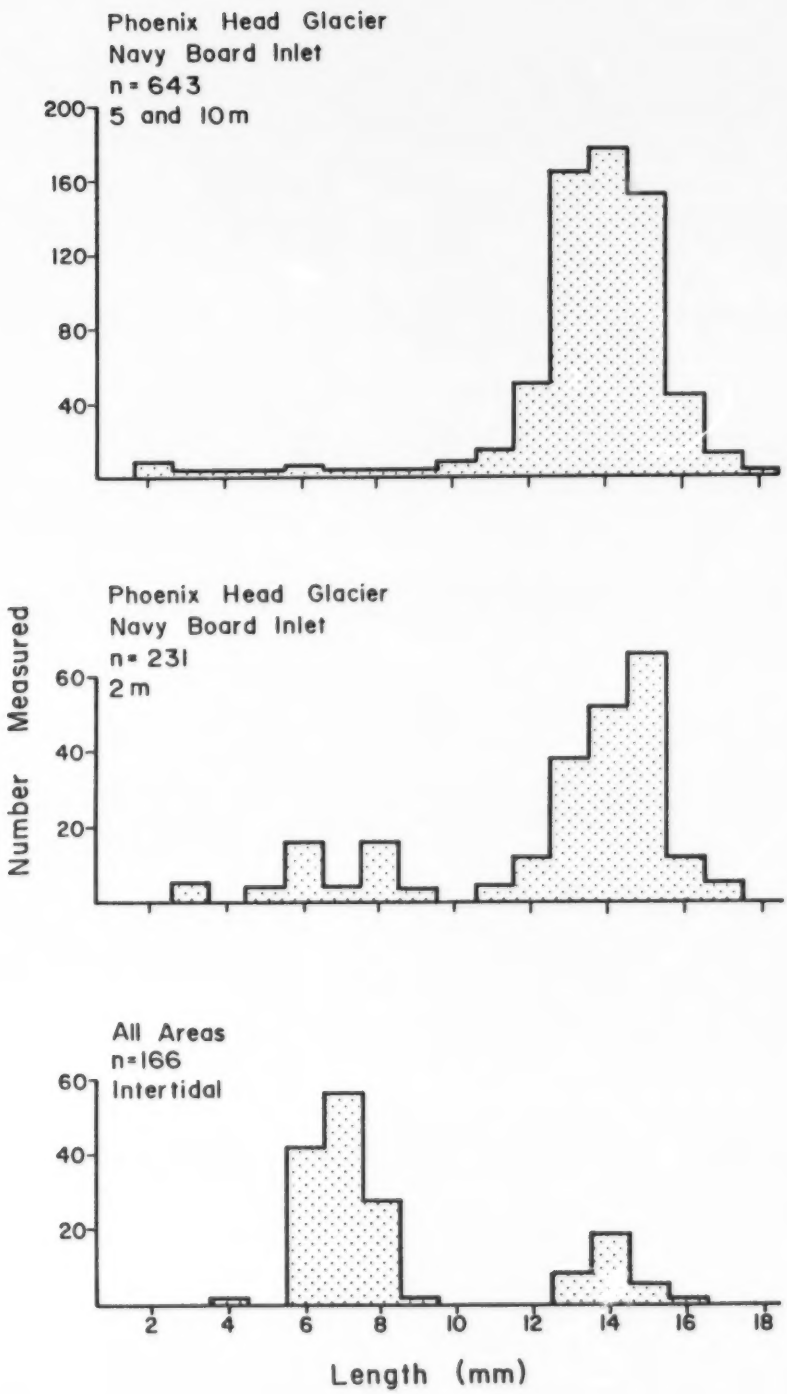

Fig. 13. Length-frequency histograms for Onisimus litoralis from intertidal, airlift and ponar grab samples collected at study sites in eastern Lancaster Sound and northeast Baffin Island during 1978. From Thomson and Cross (1980).

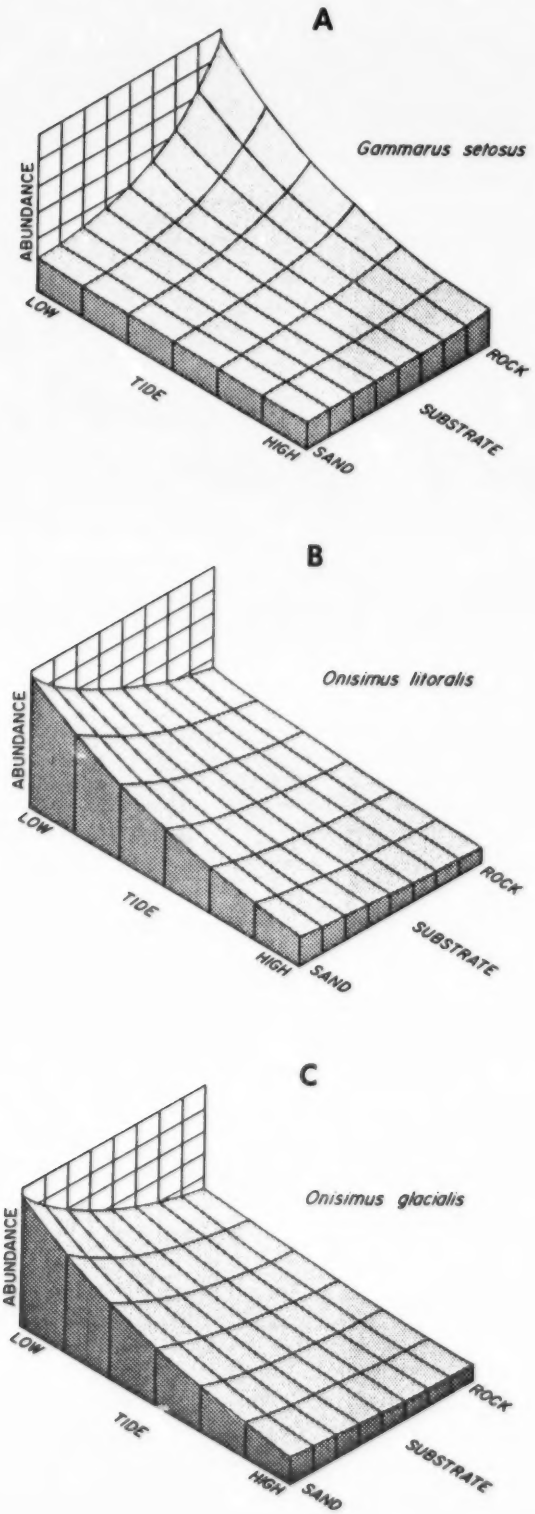

Fig. 14. Density of three intertidal amphipod species (linear scale) in relation to substrate and tide level. Plots were generated using equations produced by multiple regression analysis.